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NASA AUTHORIZATION

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BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

SECOND SESSION

ON

HOW THE UNITED STATES EQUIPS ITSELF TO BE COMPETITIVE IN SPACE IN THE 21ST CENTURY: MAINTAINING MOMENTUM IN HIGH TECHNOLOGY RESEARCH AND DEVELOPMENT

MARCH 10, 1988

PART 2

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NASA AUTHORIZATION

THURSDAY, MARCH 10, 1988

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Wichita, KS.

The subcommittee met, pursuant to notice, at 9:30 a.m., in room 207, Brown Room, Marcus Center, Wichita State University, Wichita, Kansas, Senator Nancy Landon Kassebaum presiding.

Staff members assigned to this hearing: Marty Kress and John Graykowski, professional staff members; and Pete Perkins, minority professional staff member.

Senator KASSEBAUM. The hearing will please come to order. It's my pleasure to have with us Dr. Warren Armstrong, President of Wichita State University, who will welcome us all. Dr. Armstrong.

STATEMENT OF DR. WARREN ARMSTRONG, PRESIDENT, WICHITA STATE UNIVERSITY

Dr. ARMSTRONG. Can you hear me from here? I don't speak well sitting down. It's a pleasure to welcome you to the campus of the University for this hearing. It's an important hearing. It addresses a subject that is very important to our community, to our State, and to our Nation.

In her letter of invitation, Senator Kassebaum said, and I quote, it has become apparent that Kansas is a quiet and instrumental player in the aerospace field. As far as aeronautics and aviation is concerned, the State's leadership is unquestioned. However, current economic problems make it important to explore ways to bolster and maintain our competitive edge in both aerospace and aeronautics. Only with continued research and development in science and technology, coupled with a strong educational program at all levels, can this edge be maintained, end of quote.

I concur fully with the sentiments you express, Senator Kassebaum, in that letter of invitation. And I want to share just for a moment the University's response to its opportunities to serve the aviation industry in the years since that industry first emerged here, well, back when some others were here but I was not, back in the 1920's and in the immediate aftermath of World War I. You'll probably recall the emergence of the aviation industry in Wichita, but I want to tell you about one thing that occurred 54 years ago on our campus when we were still the University of Wichita. It was in the fall of 1934 and it was an activity that took place on three campuses around the United States simultaneously. Massachusetts Institute of Technology, fondly known to us all as MIT; University

of Michigan, my alma mater and yours; and University of Wichita, now Wichita State, simultaneously introduced as a discrete and separate academic discipline for the first time anywhere in the country, the field of aeronautical engineering, and we have been a pioneer in that field ever since. We are very proud of what we've accomplished in aeronautical engineering, most recently manifested by the Institute for Aviation and Research, which four years ago was a dream, three years ago was a proposal, two years ago became a program and reality and now is a 15 million dollar plus annual enterprise on our campus.

We are delighted to have the opportunity to be a partner with aviation manufacturing and aeronautical research activities in our community and in our State, and we look forward to a very profitable discussion on campus this morning of the opportunities and challenges that confront us here in Wichita and Kansas as we seek to serve not only our State but our Nation. Thank you.

Senator KASSEBAUM. Thank you very much, Dr. Armstrong. It's a great pleasure to be on campus.

OPENING STATEMENT BY SENATOR KASSEBAUM

Senator KASSEBAUM. This morning we will be hearing the views of a number of witnesses on "How the United States Equips Itself to be Competitive in Space in the 21st Century." It is a long title but I think a very important subject, and one of which I think Kansas plays a unique role. It is a pleasure to welcome everyone here this morning to the hearing, and I am particularly greatful for the help of NASA, Wichita State University and the Commerce Committee staff which has given me so much help in preparing for this hearing.

I asked a diverse group of experts to testify about the critical elements necessary to sustain and provide renewed vigor for our Space Program. All would agree, I think, that the United States leadership in aerospace and aeronautics is a vital National priority. That leadership now is being challenged on virtually all fronts. It is essential that we simply hope for the best. We must respond aggressively to the intense competition we face in these high technology fields. It is essential for NASA to identify priorities and pursue a strategy which is practical in light of budgetary constraints and feasible in terms of technological achievements.

One part of our response must be to refocus our efforts in research and development, an area that has seen dramatic spending reductions since the days of the Apollo Program. For example, NASA's funding for space research and technology dropped from 900 million in fiscal year 1965 to 200 million in fiscal year 1987. Aeronautics research and development funding has also dropped sharply.

This trend must be reversed if we are to compete internationally. Complacency and a dwindling NASA aeronautics budget should not be the reason we lose the race for development of technologically advanced aircraft, especially since this area is the one bright spot in our trade deficit today.

While I certainly make no claim of being an expert, and I have learned a lot already from preparing for this hearing, I believe our

future successes in space must begin now at ground level with renewed attention on four basic building blocks for the decades ahead.

First, we must nurture, educate, and encourage future scientists, physicists, astronauts, and others who will make up NASA and the entire space effort of the 21st Century. This effort must begin literally at the elementary school level with programs, classes, and materials that will draw more and more students into the vital study of science and math.

Second, we must build on the strong partnership between the Space Program and our universities, where much basic research is conducted.

Third, we must also strengthen and expand existing ties between our national efforts in aerospace and encourage similar or complementary efforts in the private industry.

Fourth, we must have strong and effective leadership to direct this effort, to set priorities, and to marshal the resources essential for success. This leadership must exist at both the political level, the White House and Congress, and the administrative level within NASA.

The key question about the space program is in defining what we hope to achieve in space. The report "Leadership and America's Future in Space," states it very succinctly, and I quote:

> The U.S. Civilian Space Program is now at a crossroads, aspiring toward the visions of the National Commission on Space but faced with the reality set forth by the Rogers Commission. NASA must respond aggressively to the challenges of both while recognizing the necessity of maintaining a balanced Space Program within reasonable fiscal limits.

As I'm sure our first two witnesses will testify, this is not a simple task. But it is also not an impossible one. Many believed we would never reach the Moon, but we did.

Now we must identify our next destination, both in terms of our exploration of space and in terms of the technology necessary to reach it. Then we must develop a road map that will take us there.

To begin the hearing today, and the process we must take to find that road map, we shall hear from Dr. Noel Hinners, who is Associate Deputy Administrator of the National Aeronautics and Space Administration; and Mr. Fred Povinelli, Director for Space, Office of Aeronautics and Space Technology at NASA.

It's a pleasure to welcome both of you to Kansas. Dr. Hinners.

STATEMENT OF DR. NOEL W. HINNERS, ASSOCIATE DEPUTY ADMINISTRATOR (INSTITUTION), NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. HINNERS. Thank you, Senator. We appreciate the invitation to come to Kansas today, delighted to participate in field hearings. Frankly, I find it rather refreshing to get out of Washington and get out where the real people are.

I congratulate the Senator for putting the focus on education and technology. One might ask, "Why does NASA care?" Our basic product in NASA is knowledge. We acquire that through research and technology. We use the local of space to conduct that research. We use our ground facilities and laboratories to conduct research, and much of it goes into the aeronautics industry to help make our

Nation competitive. We have a belief that we must share that knowledge with the people who support our program, that is you. We know that the educational system is a prime vehicle for sharing that knowledge.

Our connection through technology is evident. We require forefront technology to conduct our research and exploration in aeronautics programs. The historical record is clear on this. New discoveries, new research follows on the heels of new technology. On the other side of that, the researcher is constantly after better resolution, more sensitive detecters, finding out the unknown. So, there's a technology pull. So, they work together, technology and research. We're looking for more feasible, efficient ways of escaping the bounds of the Earth's surface.

NASA needs educated people to conduct the Nation's Civil Space Program. Scientists, engineers, technicians, administrators, secretaries, all must be highly educated and literate. We need these people inside NASA. Each year, in total, we turn over about 1400 people. We must replace them. Half of those are scientists and engineers. Our industry, which conducts most of the NASA Program, actually, needs the same kinds of people. Our academic community, conducts much of the NASA Research Program, or a good part of it, needs the same types of people.

We also recognize that the country has needs that go beyond NASA's. Our very own economic well-being, our competitiveness demands an educated population. There's another benefit in that. We frequently advance the thought that the need for scientists and engineer's to help our competitiveness, but when you look at the research results that come out of space exploration, you find a remarkable story. The universe is an incredibly exciting place. It's our desire that all of our people be able to share in the excitement of finding out what nature has provided us. Education is an essential part of being able to appreciate and understand the very beauty of nature and our place in the universe.

There's a clear shortage in the country of scientists and engineers. How can NASA, how can the Space Program help this? How can we provide for our own needs? Absolutely essential is that we must have what we call a Leadership Civil Space Program that can inspire, that can attract talent, that can produce results.

The U.S. Space Program in large part, as you know, is currently grounded. We're happy to report today that we believe we're on the path to recovery. The first important thing that happened this year was that the President released the new space policy. That policy is a renewed commitment to U.S. leadership in space, for a strong science and aeronautics program, safe return of the Shuttle to flight, proceeding with the Space Station. Very important, it has declared a new National goal, which is to extend human presence and activity beyond Earth orbit into the solar system.

Policies are wonderful. We can all make them. It takes budget behind the policy. The President this year has submitted to the Congress a large NASA budget. It is one of the few Federal budgets which has increased. We believe that it is a very vigorous sign of the Presidential support for the Civil Space Program. It supports a policy, an act of NASA getting back on track. Return to flight supports the buildup of the Shuttle Flight Program from 7 flights this

next year to 10 the year after, so we get our space telescope into orbit, get our planetary mission going, get our tracking data relay satellites going, get some of our crucial military missions into space. It supports expendable launch vehicles so we don't again find ourselves in the terrible position of relying upon one launch system in the country, advanced space technology, which you will hear more about. It proceeds with the Space Station development, new science initiatives, the advance x-ray facility to look at the wonderous things that are happening, like black holes and supernovas. It rejuvenates NASA's facilities, the wind tunnels and our laboratories which have suffered neglect over the last decade and a half. All are essential if we are to return this Nation's Civil Space Program to a position of leadership. This is, in our view, the critical year for the Civil Space Program.

NASA must help produce the talents it needs. The excitement of space research, the discovery and exploration is clearly a motivator. I saw firsthand, as Director of the National Air and Space Museum many years ago, the excitement of the children who would come in there, their aspirations to participate in the endeavor of exploration and scientific and technological study. Clearly we have to convince our children that it takes hard work, study, and participation if they're going to be there when we need them.

We try to stimulate this. We have a Spacemobile Program which visits schools continually during the year. We visited 82 Kansas schools. And this afternoon, Senator, you will see one of those out at Meade Junior High School.

Teachers are critical. We cannot reach every student. We depend upon the teachers as our multiplier, if you will. We sponsor summer workshops at our NASA field centers to bring them into our daily life to show them how our research is done, to excite them, to give them an opportunity for hands-on research. The Teacher in Space Program is absolutely essential. Some people ask me, "Was it a good idea to have had a teacher on the Shuttle?" Absolutely. There's no question in my mind that it was a good idea, remains a good idea.

Summer workshops; 21 Kansas teachers were competitively selected to participate. We take math and science teachers, stimulate them, give them the materials to go back and teach the children in the schools. Educational materials we can provide to the teachers.

Hands-on involvement. We have a local school, Shawnee Mission West High School, that had five winners in the space science student involvement project. One of those went on to become a national winner, Amy Bryan.

Senator, my Bachelor's Degree, believe it or not, is in Agricultural Research. I know good land when I see it. Clearly, the fertile plains of Kansas are producing abundant food for the nations' stomachs. You know, it just occurred to me over the last few days that those fertile plains are producing keen minds to supply fuel for the Nation's Aeronautics and Space Program. Kansas should be proud of its significant contribution to the Nation's Space and Aeronautics Programs. We thank you.

[The statement follows:]

Statement of

Dr. Noel W. Hinners
Associate Deputy Administrator (Institutions)

National Aeronautics and Space Administration

before the

Subcommittee on Science, Technology and Space
Committee on Commerce, Science and Transportation

United States Senate

Madam Chairperson and Members of the Subcommittee:

Some have said Man's "Greatest Adventure" was the Apollo voyage to the moon and back. Perhaps, but on a wider plane this was but a first step in what to many is the most exciting adventure of all -- the kindling of the minds of the young to explore the universe. I would like to use the opportunity this morning to briefly describe the President's recently released space policy, how NASA's program implements the policy, and finally, the important elements of the civilian space program. The President on February 11, 1988, issued a new National Space Policy setting the nation's path for space activities well into the next century. The policy sets forth six goals for United States space activities: (1) to strengthen the security of the United States; (2) to obtain scientific, technological, and economic benefits for the general population and to improve the quality of life on Earth through space-related activities; (3) to encourage continuing private-sector investment in space and related activities; (4) to promote international cooperative activities taking into account United States national security, foreign policy, scientific, and economic interests; (5) to cooperate with other nations in maintaining the freedom of space for all activities that enhance the security and welfare of mankind; and, as a long-range goal (a goal of imagination and motivation for the young), and (6) as a long-range goal, to expand human presence and activity beyond Earth orbit into the solar system.

UNDER CIVIL SPACE POLICY THE DIRECTIVE STATES THAT:

> "The United States civil space sector activities shall contribute significantly to enhancing the Nation's science, technology, economy, pride, sense of well-being and direction, as well as United States world prestige and leadership. Civil sector activities shall comprise a balanced strategy of research, development, operations, and technology for science, exploration, and appropriate applications."

"The objectives of the United States civil space activities shall be (1) to expand knowledge of the Earth, its environment, the solar system, and the universe; (2) to create new opportunities for use of the space environment through the conduct of appropriate research and experimentation in advanced technology and systems; (3) to develop space technology for civil applications and, wherever appropriate, make such technology available to the commercial sector; (4) to preserve the United States preeminence in critical aspects of space science, applications, technology, and manned space flight; (5) to establish a permanently manned presence in space; and (6) to engage in international cooperative efforts that further United States space goals."

This policy not only reaffirms NASA's commitment of safe return to flight, development and operation of a permanently manned Space Station, exploration of the solar system with ongoing and planned missions, and pursuit of aeronautical and space research, but also presents a significant challenge for forging the future of NASA. Dr. Fletcher, NASA's Administrator, on release of the policy, said: "This is a policy of investment in the future. It lays the necessary groundwork now for the decisions of the next century. It puts the challenge squarely on NASA. And it is a challenge we accept."

However, as we look toward this future, and in fact, as has become evident today, the United States is producing fewer and fewer scientific and engineering graduates. The trained innovators and technological explorers are critical to the success of not only NASA's programs, but the overall technological future of the nation. While there may be many reasons that such a situation has developed, it seems that certainly a most basic one for young potential scientists and engineers is individual motivation; understanding and accomplishing what is educationally required and having a vision for participation in the grandest of adventures -- humanity's exploration of the universe.

Madam Chairperson, a significant provision of the President's Commercial Space Initiative, issued in conjunction with the National Space Policy, calls for the use of educational opportunities to build a solid talent base of scientists, engineers, and technicians to accomplish America's long-range space goals. Beyond that, it establishes goals which provide the incentive for students to enter the scientific and engineering disciplines...knowing that challenges and disciplines will exist for them throughout an entire career.

This initiative reaffirms the thrust of our NASA five-year educational affairs plan to work with the nation's pre-college and university community.

At NASA, we are working on a number of initiatives to meet the national challenge of stimulating the educational development of the future innovators and leaders of both the space program and an ever more demanding technological society. We are concerned about our ability to compete in today's market for outstanding scientific and engineering talent. We are also concerned about modernizing and enhancing the agency's institutional capabilities, i.e., the core capability of personnel, equipment, and facilities. I would like to expand upon these initiatives with you this morning.

1. PRE-COLLEGE AND UNIVERSITY INITIATIVES:

NASA's educational plan priorities include elementary education, teacher education, underrepresented minority participation, educational technology, and aerospace education services as well as college and university programs. An excellent intellectual stimulus for students, teachers, and university faculty is provided when NASA's work regarding Space Shuttle, planetary probes, remote sensing, Hubble Space Telescope, and Space Station are converted into user-friendly educational materials activities, and programs.

As examples of how these programs interact with state and community education programs, lets discuss those here in Kansas. Over the years, NASA-supported educational activities in the state of Kansas have been substantial. For example:

a. Our aerospace education services program, commonly called "space mobile," sends aerospace education specialists to conduct classroom lectures and assemblies in elementary and secondary schools around the country. Visiting some 2,000 schools per year, the spacemobilers have visited 82 Kansas schools. In fact, the space mobile will be visited by you and your staff this afternoon at the Meade Junior High School.

b. Kansas has produced 21 high school teachers who were competitively selected to participate in our NASA education workshop program for math and science teachers (NEWMAST). Having reached some 800 teachers nationwide over the past four years, these teachers spend two weeks in one of our research and development centers working with scientists and engineers on projects and activities that enhance teaching approaches when they return to the classroom.

c. During 1986 and 1987, our aerospace specialists conducted 14 teacher workshops at 6 universities and colleges in Kansas. Nationwide, we have conducted 252 teacher workshops at 169 colleges and universities.

d. Kansas has also been prominently represented in our NASA space science student involvement program (SSIP). In this program, students compete nationwide in designing space science projects concerning microgravity, wind tunnel, and space station research. They also design Mars colony projections through art and participate in student newspaper competitions. Last year, 5 of the 39 regional winners of the Space Station competition were from Shawnee Mission West High School in Shawnee Mission, Kansas. One of those five, Amy L. Bryan, a tenth grade biology student, was one of the 7 national winners. Her project was entitled "The Effects of Microgravity Environment on the Production of Pearls." Direct participation in research, with its attendant excitement, is one of the best ways we know of to stimulate our students.

e. Two of the outstanding nationally selected "Teacher in Space Ambassadors" for Kansas are Mr. Wendell Mohling from Shawnee, Kansas and Mr. Barry Schwartz from Kingman, Kansas.

f. During FY 1986, NASA supported 51 active research grants and contracts at the University of Kansas and Wichita State University, funded at $1.37 million.

In sum, the range of aerospace and space science educational activities in Kansas represents a significant effort to help assure that the nation's future work force has a solid talent base to help America achieve its critically important space goals.

2. ALTERNATIVE PERSONNEL SYSTEM INITIATIVE

NASA's need to recruit and retain top-quality talent is increasingly convincing us that some reform of the personnel system is justified and necessary in the near future. This need has also been identified by the President, the Office of Personnel Management, and many in Congress.

Historically, NASA has been able to compete quite well for scientific, engineering, management and other kinds of talent because of the exciting nature of our mission, our unparalleled facilities, the educational opportunities we offer, and the challenging jobs individuals are given to perform. However, in our field centers such as the Ames Research Center in California and the Goddard Space Flight Center in Maryland, which are

located in areas surrounded by high technology firms, we are finding it increasingly difficult to compete with the private sector in recruiting top-quality graduates and the best executives in the scientific and engineering community. NASA's interest in simplifying the personnel process is the result of indicators that the Government's personnel system is not working as well as we need it to work. While numerous legislative proposals have been set forth, the Administration's Civil Service Simplification Act (CSSA) would improve substantially the Government's personnel system and provide NASA with needed flexibility in the personnel area. It is responsive to our problems.

Our experience shows that to be more effective, managers need to have more control over rewards and incentives to encourage better performance; managers want to strengthen the linkage between work accomplishments and pay consequences. Additionally, a simplified system of job classification with broader, more general pay levels would provide needed flexibility. These changes could be expected to result in significant reduction in the paperwork burden, the flow of documentation, and the volumes of administrative rules. Even more important, these changes would strengthen the human resources management performance of line managers and supervisors.

We believe that reforms which recognize and accommodate the differences among Government agencies -- the diversity in culture, values, problems, work force skills, and needs -- are critical to accomplishing NASA's mission. NASA wants and needs a personnel system that is more modern, flexible, and creative than the current system. Such change is necessary in order to meet current and future challenges of the Nation's Civilian Space Program.

3. NASA INSTITUTIONAL INITIATIVES

As mentioned earlier, NASA is concerned with the continued strength of its infrastructure, the NASA institution. As you may know, the position I presently hold was created this past year to provide additional management focus on and coordination of the institutional aspects of NASA. Our efforts this past year have been directed at reversing a deteriorating institutional situation. The successful execution of this effort is of the most critical nature as the NASA institution forms the basis of our ability to provide the capability necessary to return the Shuttle safely to flight; organize and staff the Space Station; maintain our capability to conduct space science and applications missions; and continue successful first quality aeronautics and space research activities. Further, without a strong

institutional base, we will be severely limited in reaching for and accomplishing the future research and development activities without which the United States cannot maintain its technological and competitive position in the world.

The traditional strength of the NASA organization has been the people, their expertise and experience, and their desire to accomplish, with excellence, the civil aeronautics and space programs and projects of the nation. Additionally, in order for these people to do their best work, NASA has needed modern world class research centers, facilities and equipment.

Following the Challenger accident, NASA conducted the most in-depth analyses of its institutional base since the mid-1970's. Analyzed areas included the people and their skills and the agency's facilities and equipment, i.e., NASA's infrastructure. These studies showed that during the time when considerable attention was focused on the development and early operations of the Space Shuttle and exciting unmanned exploratory missions to the planets, not enough emphasis was placed on maintaining the health and vitality of NASA's institutional base. It has now become abundantly clear that a research and development organization, like NASA, needs to take a long view toward seeking to match the capabilities of its staff, facilities, and equipment with its evolving work tasks as advances are made in research and development. The programs the agency seeks to undertake in the future will require a modernized and enhanced institutional base.

As you know, our institutional requirements are funded through the Construction of Facilities (CoF) and the Research and Program Management (R&PM) appropriations. The FY 89 CoF and R&PM budget requests address our need for a strengthened institutional infrastructure. These requests are submitted based on considerations of multiyear institutional needs required to maintain a sufficient investment and reinvestment to support the agency's capability to accomplish its approved aeronautics and space programs. The CoF budget request for FY 1989 of $285,100,000, with estimated outlays of $178,000,000, provides for an incremental effort to restore and modernize NASA's facilities. Also, it reflects estimates for Space Station and Space Flight requirements that are time sensitive to meeting specific program objectives and supports other key projects needed to maintain the institutional infrastructure. The FY 1989 R&PM request of $1,915,000,000 will provide funding for the 22,950 permanent and temporary civil service work years (FTE) which constitute NASA's most important resource -- its expert and dedicated civil service staff. Additional objectives of the R&PM request are: to provide this staff with technical and management

skills, to provide for base maintenance of NASA's facilities, and to provide effective and efficient technical and administrative support to NASA's R&D programs.

Another area concerning our work force, of which NASA is quite proud, is the progress being made toward more representation of minorities and non-minority women among our employees. For example, of the 1,025 scientists and engineers hired or converted from the co-operative education program this past year, 362 (35.3 percent) were minorities and non-minority women. Also, once hired these same groups are demonstrating their upward career mobility in the scientific and engineering fields, last year of 2,195 promotions earned by our scientists and engineers, 728 (33.2 percent) were earned by minorities and non-minority women.

Because these areas concern significant components of the NASA institutional base, I have appended a fuller description of the FY 1989 CoF, and R&PM budget request and more information about our EO activities.

In closing, the President has established a bold space policy for the present and the future. We have accepted this challenge and have the will to carry it out. The NASA institution provides the basis on which we will continue to build a technologically sound civil space program which will help the United States maintain a favorable competitive position in an ever increasing technologically competitive world. Also, a program that will serve as a catalyst to motivate America's young people toward educational attainment. With motivated and knowledgeable people, the nation will have the most critical tool necessary for man's greatest adventure -- the exploration of the universe.

I would be pleased to answer any questions you may have.

APPENDIX

Construction of Facilities (CoF)

The Construction of Facilities appropriation provides contractual services for the repair, rehabilitation and modification of existing facilities, the construction of new facilities; the acquisition of related facility equipment; the design of facilities projects; and advance planning related to future facilities needs.

The funds requested for FY 1989 provide for the continuation of prior-year endeavors in meeting the facilities requirements for the Space Flight and Space Station programs; initiation of a structured multiyear effort to restore and modernize NASA's aeronautical research and development facilities; repair, rehabilitation and modification of other facilities to maintain, upgrade, and improve the usefulness of the NASA physical plant; minor construction of new facilities, facility planning and design activities, and environmental compliance and restoration.

The projects and amounts in the budget estimates reflect Space Station and Space Flight requirements that are time sensitive to meet specific program objectives. Other program requirements for 1989 include construction of an auxiliary chiller facility at the Johnson Space Center, modifications to the X-Ray Calibration Facility to support the Advanced X-Ray Astrophysics Facility Program at the Marshall Space Flight Center, modernization of the Space environment Simulator and modifications for utility reliability at the Goddard Space Flight Center, refurbishment of the 25-Foot Space Simulator at the Jet Propulsion Laboratory, projects to repair, restore, and modernize NASA's aeronautical research and development facilities at Ames, Lewis, and Langley Research Centers, and refurbishment of the electric Power Laboratory at the Lewis Research Center.

The FY 1988 program continues to meet the objectives of preserving and enhancing the capabilities and usefulness of existing facilities and ensuring safe, economical, and efficient use of the NASA physical plant. This request continues the necessary rehabilitation and modification program begun in prior years and continues a repair program. The purpose of the repair program is to restore facilities to a condition substantially equivalent to their originally designed capability. The minor construction program continues to provide a means to accomplish smaller facility projects which accommodate changes in technical and institutional requirements. The Environmental Compliance and Restoration Program will ensure that statutory environmental requirements will be met and any necessary remedial action promptly taken.

Funds requested for facility planning and design cover advance planning and design requirements for potential future projects, master planning, facilities studies, engineering reports and studies, and the preparation of facility project design drawing and bid specifications.

The budget authority requested for FY 1989 is $285,100,000, with estimated outlays of $178,000,000.

Research and Program Management (R&PM)

The Research and Program Management appropriation funds the performance and management of research, technology, and test activities at NASA installations, and the planning, management, and support of contractor research and development tasks necessary to meet the Nation's ongoing objectives in aeronautical and space research. The objectives of the activities funded by the Research and Program Management appropriation are to (1) provide the civil service staff with the technical and management skills to conduct the full range of programs for which NASA is responsible, (2) provide base maintenance of facilities and manage its use in support of research and development programs, and (3) provide effective and efficient technical and administrative support for the research and development programs. For 1989, an appropriation of $1,915,000,000 is requested.

The 1989 Research and Program Management appropriation request provides funding for the 22,950 permanent and temporary civil service work years (FTE) at eight major installations and Headquarters. This civil service work force is NASA's most important resource and is vital to future space and aeronautics research activities. At the direction of the Committees on Appropriation, NASA, beginning in 1988, has realigned the R&D/SFCDC and R&PM appropriation structures. In the realigned R&PM appropriation, about fifty nine percent provides for the salaries and related costs of the civil service work force. Three percent is for travel, critical to manage successfully the agency's in-house and contracted programs. The remaining amount of the Research and Program Management appropriation provides for the research, test, and operational facility support, and for related goods and services necessary to operate efficiently and effectively the NASA installations, and to accomplish NASA's approved missions.

The 1989 Budget estimate of $1,915,000,000, an increase of $172.0 million over the current 1988 R&PM plan, provides for: a civil service ceiling of 22,950 work years (an increase of 525 FTE from 1988), the funds needed to continue previously planned necessary operations, the full year cost of the 1988 pay raises,

security/protection for the Space Transportation Systems as a national resource; conduct of definitional review/studies for the OMB required "centralized" Financial and Accounting System; establishment of a NASA Project Management Institute; an adequate level of travel to support agency missions and programs; support service contractor effort at the anticipated wage-rates; utility usage consistent with programmatic requirements at projected rates; and supplies, materials, equipment and other minor contracts and services at anticipated price levels consistent with the planned resumption of Space Shuttle Flights.

The Research and Program Management appropriation request for 1989, by functional category is summarized below.

a. Personnel and Related costs ($1,131,008,000): The 1989 estimated for Personnel and Related Costs is $94.0 million higher than 1988. Of the increase, $42.0 million is related to the 1988 reductions (shown in Center justifications as permanent compensation and retirement), $6.1 million is for the full-year cost of 1988 pay increases, $23.8 million for the compensation, benefits and supporting costs for the 525 additional FTE, establishment of a project management institute ($2.0 million) and the balance ($20.1 million) is for changes in reimbursements received, career development costs and other changes in salaries and benefits paid. (Note: The full civil service staffing increase needed to manage the Space Station adequately and to revitalize the NASA institution fully will be the subject of further review with OMB in the spring of 1988.)

b. Travel ($51,000,000): Because the vast majority of NASA funds are spent for activity in the private sector (over 85 percent), travel for both programmatic and management purposes is integral to the effective and economical accomplishment of program objectives. In addition, because NASA's civil service work force is so heavily technical (over 50 percent of NASA's permanent personnel are degreed scientists and engineers) travel to scientific and technical meetings, seminars and symposia is important for the interchange of information and maintenance of their technical currency. In 1989, the growth in travel over 1988 is associated with the added positions and the expected rise in the general cost of transportation, per diem, and miscellaneous travel expenses, as well as the anticipated demands of project and other management travel.

c. Operation of Installation ($732,992,000): The 1989 plan provides for anticipated changes in the price levels of support service contractor wage rates and utility rates, the alteration in the funding plans from reimbursable launch vehicle activities, the change in price levels for supplies, materials, and

equipment, and minor changes in the levels of support provided as center requirements change and Space Shuttle flights resume. In addition, funds are requested to support the authorized work force in 1989, the security improvements for STS, and the start of the NASA part of a governmental "centralized" financial and accounting system.

1. Facilities Services ($302,588,000): The 1989 estimate, an increase of $30.5 million over the 1988 current estimate, covers the anticipated rate and price increases for utilities support contractor wage rates, supplies, materials, equipment, and minor contractual effort, minor changes to support levels, principally needed as Space Shuttle flights resume, and support to increased civil service staffing and the security improvements for STS.

2. Technical Services ($183,958,000): The $18.7 million increase in 1989 covers anticipated support service contractor wage rates, the anticipated cost of supplies, materials, equipment, and other contractual efforts, support to increased civil service staffing and the "centralized" Financial and Accounting Systems.

3. Management and Operations ($246,446,000): The $20.5 million increase in this subcategory is the result of the support to increased civil service staffing, increased costs of supplies, materials, equipment, and minor contractual effort, the anticipated change in support service contractor wage rates, and the changes in levels of support required, driven chiefly by the resumption of Space Shuttle flights.

In summary, the 1989 budget requirement of $1,915,000,000 is to provide for 22,950 full-time equivalent, civil service work years and to support the activities at eight NASA installations and Headquarters, consistent with the Research and Development, Space Flight, Control and Data Communications, and Constructions of Facilities program plans.

Equal Opportunity

NASA continues to make progress in increasing the representation of minorities and non-minority women among our employees; at the end of FY 1987 they were 40.9 percent of the agency's total work force, up from 39.6 percent in FY 1986. Increased representation was achieved for minority men and women and for non-minority women Scientists and Engineers (S&E) and for non-minority women in Professional Administrative (Prof. Adm.) positions. Our

percentages decreased for minority males in the Professional Administration positions for all three groups in the Senior Executive Service (SES).

	S&E		Prof. Adm.		SES	
	FY 86 %	FY 87 %	FY 86 %	FY 87 %	FY 86 %	FY 87 %
Minority Men	8.0	8.5	7.1	6.8	4.5	3.7
Minority Women	1.7	1.9	8.0	8.0	0.5	0.4
Non-Minority Women	8.1	8.9	33.2	34.9	3.3	2.6

As of the end of FY 1987 there were 12 non-minority women, 1 minority woman and 5 minority males in the Astronaut group, a 18.6 percent combined representation. Other related information is presented below:

Hires:

a. Of 1,025 scientist and engineers hired or converted from the cooperative education program: 362 (35.3%) were minorities and non-minority women.

b. Of 281 hires and conversions from nonprofessional positions in professional administrative occupations: 155 (55.2%) were minorities and non-minority women.

c. Of 998 other hires: 678 (67.9%) were minorities and non-minority women.

Promotions:

a. Of 2,195 scientists and engineers: 728 (33.2%) were minorities and non-minority women.

b. Of 761 in professional administrative positions: 543 (71.4%) were minorities and non-minority women.

c. Of 1,310 other promotions: 995 (76.0%) were minorities and non-minority women.

In addition, 27 handicapped persons with targeted disabilities were hired, exceeding NASA's goal by 10. As of the end of FY 87, NASA employed 184 persons with targeted disabilities (183 last year).

Senator KASSEBAUM. Thank you very much, Dr. Hinners. Mr. Povinelli.

STATEMENT OF FREDERICK P. POVINELLI, DIRECTOR FOR SPACE, OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. POVINELLI. Madam Chairman, it's truly a pleasure for me to be here this morning to discuss NASA's Space Technology Program. Several recent, exciting developments have revitalized this program, and I am delighted to have the opportunity to discuss them with you.

As Dr. Hinners has just mentioned, in February, President Reagan issued a new national space policy designed to guide the Nation's activities in space well into the next century. The policy reaffirms U.S. leadership in space as a fundamental National goal.

NASA's Space Technology Program plays a major role as we strive to meet the challenge of expanding human presence into the solar system. In fact, a new space policy specifically calls for the initiation now of critical Pathfinder technologies. These technologies will help develop the understanding and allow a future administration to decide on specific piloted exploration missions and timetables for them.

The picture for the Space Technology Program was not so rosey not so long ago. As we scrutinized ourselves and others outside scrutinized us after the Challenger accident, we came to the realization that we had been underinvesting in the Technology Program for many years and, in fact, had been eating our technology seedcorn. We anticipated the new visions of the future and we initiated a long needed systematic effort to revitalize all aspects of our Technology Program. Key elements of this were to strengthen our technical activities, to strengthen our partnership with industry and universities, and to conduct experiments in a space environment when required. The Civil Space Technology Initiative, what we refer to as CSTI, was the first step in strengthening our Technology Program. It was initiated, with your support, in Fiscal Year 1988. It focuses on developing the engineering understanding necessary to enable reliable and efficient access to space—the technology for getting to, operating in, and conducting science in low-Earth orbit. The Pathfinder Program moves outward from low-Earth orbit to address the essential technologies that will enable a broad range of piloted and unpiloted missions. It is proposed as a key element in NASA's Fiscal Year 1989 budget request currently being considered by the Congress.

Pathfinder continues building the Nation's technology base and extends the foundation being established under CSTI. Pathfinder will focus on four major program thrusts: technologies for exploration, operation, long-term presence of humans in space, and transfer vehicle technologies. Some of the critical advances required are surface mobility for planetary rovers, autonomous sample acquisition and analysis, understanding human performance and health for long-term presence in space, life support systems that are closed where the air, water and waste can be replenished, chemical transfer and cryogenic fluid depot technologies for permanent space stations of vehicles. These are but a few of the 17 technology elements in the Pathfinder Program.

Pathfinder foresees a future that builds on the Space Shuttle and Space Station. It addresses technologies that will support a wide range of possible future space missions. These include a return to the Moon to build an outpost, piloted missions to other planets, and continual exploration of the Earth and the rest of the solar system. Pathfinder will build a solid foundation upon which future decisions for new space missions can be made and help enable the visions shown in the National Commission on Space and Dr. Sally Ride's report.

CSTI and Pathfinder, however, are not all that it will take to fulfill the challenge of reaffirming U.S. leadership in space. Partnerships with industry, academia and other government agencies are critical. We are working hard to develop relationships with the aerospace community similar to those we have had for over 70

years in aeronautics. We are expanding space technology partnerships among the experts at NASA's centers, U.S. industry, and U.S. universities.

For example, during the past year, we initiated an Outreach Program to facilitate access to the Shuttle and eventually the Space Station for technology experiments by the industry and universities. Their response to our first solicitation was extremely positive. The proposals encompassed all of the engineering disciplines and came from all regions of the country and many were joint industry and university proposals. Clearly, we have touched a vital reservoir of engineering interest and need.

We have also begun a very intensive activity to strengthen our partnerships with universities. We believe that by providing a set of challenging future space goals, we will catalyze the interest and enthusiasm of today's university students so that they will consider engineering careers in space research. Universities have always played an important part in the NASA Space Technology Program. We are expanding that role so that we can meet the challenge of continued U.S. space leadership.

One new program in our university activities I would like to highlight is one called the University Space Engineering Research Center Program. This will provide support to universities for multidisciplinary research centers and is designed to bring together the knowledge, methodologies, and engineering tools needed to advance future space systems. It is intended to remedy the decline in availability of qualified space engineers by making long-term commitments to universities interested in strong engineering roles in the Civil Space Program.

We announced this new program in the summer of 1987, and like the response we received for the Outreach Program for in-space experiments, we received an enthusiastic response, 115 proposals from throughout the country. We are evaluating the proposals now, and announcements of awards of the first eight universities will be made next month. We are very excited about this new relationship and new expanded role with our universities.

In summary, the NASA Space Technology Program is clearly growing and taking on a new and more vital role in strengthening our partnerships with the industry and the university communities, revitalizing the technology base through CSTI and Pathfinder, and responding to the challenge of a new, long-term vision of U.S. leadership in space.

Senator, thank you for this opportunity to discuss these exciting new space technology ventures, and I would be happy to answer any questions you might have.

[The statement follows:]

STATEMENT OF FREDERICK P. POVINELLI, DIRECTOR FOR SPACE, OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NASA

Madam Chairperson and Members of the Subcommittee:

On February 11, 1988, President Reagan issued a new National Space Policy designed to guide the Nation's activities in space well into the next century. The policy confirms the basic goals of United States leadership in space. It establishes a strong commitment to get the Space Shuttle safely back in operation, to proceed with the Space Station as the key to leadership, and to continue a balanced Space Science program. The policy reaffirms the President's strong commitment to encouraging a healthy and expansive commercial space industry. The policy clearly establishes that, for the first time, the United States has a long-range goal of expanding human presence and activity beyond Earth orbit into the solar system. As a first step the policy focuses appropriately on the emerging and innovative "Pathfinder" technologies that will allow a future Administration to decide with confidence on specific manned exploration missions and timetables to meet them.

FUTURE DIRECTIONS

The space policy will energize national debates on the long term directions of the civil space program. As the multitude of potential scenarios are discussed, the directions that emerge will better define the requirements on the Nation's launch capabilities and the utilization and evolution of the Space Station. Some of the possible themes of the future scenarios are described in Dr. Sally Ride's report entitled, "Leadership and America's Future in Space."

CIVIL SPACE TECHNOLOGY INITIATIVE

In anticipation of and in response to these new visions of the future, the leadership in NASA undertook a long-needed systematic strategy to revitalize the Space Research and Technology program and to strengthen the partnership with the aerospace industry and universities. Using the Research and Technology Base as a seedbed of ideas and programs, the Civil Space Technology Initiative (CSTI) was initiated in FY 1988 as the first step to fill gaps in our technology base and to develop the detailed engineering understanding necessary to enable the future of the civil space program.

CSTI is directed at research and technology to enable reliable and efficient access to space and to support space operations and science missions. NASA is moving out successfully on the program; we are developing new and innovative management approaches to insure successful implementation of focused R&T programs such as CSTI.

In the development of technologies for transportation to, and operations in, Earth orbit, CSTI will address reusable, high-performance engines, advanced boosters, and demonstration of aerobraking use of the atmosphere, rather than propellant, to slow an orbit transfer vehicle returning to low Earth orbit at moderately high velocities. CSTI will enhance Earth-orbit operations through development of autonomous systems, space robotics, and high capacity power conversion technologies. Finally, science mission operations will be enhanced or enabled through CSTI programs in precision segmented reflectors for large space observatory, science sensors, large space structures and their control, and high capability in-space data systems research.

PATHFINDER

Project Pathfinder is the next critical step, after CSTI, to ensure long-term U.S. leadership in space. It will develop technologies to enable a broad range of possible future space missions. Project Pathfinder addresses opportunities afforded by the advancement of high-leverage technologies, focusing on four major program thrusts.

Exploration technologies will be developed for the gathering of scientific and other technical knowledge and understanding at mission sites on other bodies in the solar system. Specific objectives include the capabilities needed to precede robotic or piloted missions of solar system exploration. Program elements are planetary rover; sample acquisition, analysis, and preservation technologies; surface power; and optical communications.

Operations technologies will advance U.S. capabilities in Earth orbit, as well as for lunar and planetary missions. Specific objectives include capabilities for in-situ materials processing, fabrication, and assembly and repair of massive and complex systems in Earth orbit and at lunar and planetary orbits and surfaces. Program elements are rendezvous and docking, resource processing pilot plant, in-space assembly and construction, cryogenic fluid depot, and space nuclear power (SP-100).

Humans-in-space development is intended to find ways to make it both feasible and productive to send astronauts on lengthy missions. Specific objectives include enabling astronauts to conduct long-duration missions with affordable risk and minimal dependence on resupply of expendables. Program elements are extra-vehicular activity/suit, human performance, and closed-loop life support system.

Transfer vehicle technologies will advance U.S. capability in transportation for future lunar and planetary missions. Specific objectives include significant reductions in the mass launched into low Earth orbit, and in transit, as well as reductions in the time required for transit. The program elements are chemical transfer propulsion, cargo vehicle propulsion, high energy aerobraking, autonomous lander, and fault-tolerant systems.

Pathfinder represents a planned, deliberate phasing for the Nation's future in space. It is a research and technology program that will enable a broad set of potential new missions in space exploration and strengthen the technology base in support of the civil space program. Pathfinder extends the foundation established under CSTI.

Pathfinder, with a longer-term horizon, foresees a future that builds on the Space Shuttle and Space Station and addresses technologies that will support a wide range of possible future space missions including a return to the Moon to build an outpost, piloted missions to other planets, and continuing exploration of the Earth and the rest of the solar system. Early proof-of-concept testing of mission critical engineering designs will be an important element of the overall program. Pathfinder will build a foundation upon which future decisions for new space missions can be made, although Pathfinder does not represent, in itself, any commitment to a specific mission or set of missions.

CSTI and Pathfinder will also serve as a vital stimulus to reinvigorate and augment the space technology engineering talent pool both within the government and in the entire aerospace community. By providing a set of challenging future objectives for the civil space program, NASA hopes to catalyze the interest and enthusiasm of today's university students so that they will become the aerospace community of the Nation in the future.

PARTNERSHIP WITH THE AEROSPACE INDUSTRY AND UNIVERSITIES

In addition to a new emphasis on focused technology programs, it is NASA's intent to bolster the Nation's civil space research and technology base by broadening and strengthening the participation of both industry and academia.

NASA has, of course, had a long history of working with the aircraft industry. The National Advisory Committee on Aeronautics (NACA) was chartered to "direct and conduct research and experiments in aeronautics." And, the expertise and facilities developed within the NACA have proven to be of great importance to the emerging U.S. aviation industry and to national defense. One of the many contributions is the development of the NACA cowling for radial engines which received the 1929 Collier Trophy. Another is the research on skin-friction drag reduction by maintaining laminar boundry-layer flow, an area that has a specific application to general aviation. The feasibility of the approach was demonstrated recently with an advanced technology wing tested on a Cessna 210 under a joint NASA/Cessna research program. NASA cooperative programs with the general aviation industry are a very important part of the aeronautics technology program that will continue to be nourished in the future.

An expansion of the space technology partnership is also being built among the experts at NASA Centers, U.S. industry and U.S. universities. During the past year, an out-reach program to facilitate access by the aerospace community to national facilities such as the Space Station and the Space Shuttle has been initiated. The response to our first solicitation for space experiments was very positive, encompassing all the engineering disciplines and all regions of the country. Clearly we have touched a cache of engineering interest. The extent of the program is only limited by the agency's capabilities to assist in the development and integration of these proposals into the space technology in-space engineering test program.

An integral part of the strategy to rebuild the space technology base is to enhance and broaden the involvement of the Nation's university engineering community in the U.S. civil space program. Universities have always played an important part of the NASA space technology program, with approximately 10% of the program supporting university grants and contracts. The new program is intended to remedy the decline in the availability of qualified space engineers by making a long-term commitment to universities aspiring to play a strong engineering role in the civil space program. The program also seeks to provide the inspiration for the brightest and the most energetic of the Nation's youth to consider a career engineering the Nation's future in space.

The University Program in Space Technology includes three elements: the university grants and contracts that are an integral part of the NASA discipline technology programs; the University Space Engineering Research Program that supports multidisciplinary research centers; and the NASA University Advanced Design Program which funds advanced systems study courses at the senior and graduate levels.

The University Space Engineering Research Center program is designed to advance the traditional space engineering disciplines and bring together the knowledge, methodologies, and engineering tools needed to advance future space systems. The university research centers promote the kind of multidisciplinary teamwork that technological systems problems demand and bring individuals from a wide range of engineering and scientific fields into a single research endeavor. These partnerships provide the universities with a broader charter for independent research and stimulate the conception of new missions and technical alternatives that will broaden the options available to NASA in defining future mission approaches. In the summer of 1987, the Office of Aeronautics and Space Technology issued a solicitation calling for proposals. In response, 115 proposals were received and are currently under evaluation. Announcement of awards to the first eight universities is planned for next month.

The objectives of the NASA University Advanced Design Program are to foster engineering design education in the universities and to supplement NASA's in-house efforts in advanced planning for aeronautics and space systems design. The program is centered on university engineering design courses that address specific engineering problems or future missions. During 1988, design studies included a lunar storage and transfer system, variable artificial gravity facilities for the Space Station, ram accelerator direct launch systems, long-term space habitat, construction equipment for a lunar base, and a Mars oxygen processor demonstration unit. The University of Kansas participated in a companion aeronautics engineering program studying supersonic transports. The university advanced design program has been an effective mechanism for integrating the educational objectives of the university community with the advanced engineering design interest of NASA. The program was expanded in 1987 from the original nine schools to a total of 31 universities working cooperatively with eight NASA Centers.

CONCLUDING REMARKS

Historically, technology has been a cornerstone of our leadership in space. What was once an unquestioned area of U.S. preeminence--the civil space program -- is now increasingly a field with shared leadership. The President's Space Policy puts the civil space program back on a firm policy footing. The new long-term goal of human exploration of the solar system beyond low-Earth orbit and the first steps of

revitalizing the technology base are important, necessary initial steps. The technologies required to enable advanced transportation to and operations in Earth orbit and to enable next-generation science missions are being developed in CSTI. That initiative was founded on a decade of research in emerging technologies and meets identified priority needs of NASA and national programs. Pathfinder is the next, right step in order to meet the goal of continued U.S. space leadership. Engineering universities are being positively motivated to increase research activities supporting the Nation's future in space and to provide the new engineering talent that will make our vision of the future a reality. The next major challenge will be to insure the utilization of developing in-space facilities, both for basic research and to guarantee rapid, cost-effective mission application of new space technologies.

I was pleased to be able to discuss some details of the Space Research and Technology program. It reflects a long-term vision for the Nation's technological capability to achieve lasting leadership in space by providing the engineering understanding required to make wise decisions on future missions.

Thank you for the opportunity to provide this testimony. I would be happy to answer any questions that you may have.

Senator KASSEBAUM. Thank you. I do have a couple of questions I would like to ask you. Maybe the two of you can decide who will respond to the questions. One is that we've talked a lot about the Challenger accident and the loss of momentum at that time, and I think this loss perhaps went back even before the Challenger tragedy. How do we refocus our attention on the importance of space to give it the sense of mission that we had with the Apollo Program? I notice there's been a calculated effort on the part of NASA to not have the focus on just one program. But on the other hand, I think many today view NASA as just another Federal program. Is there some way by which we can refocus or provide a more direct focus through NASA's efforts?

Dr. HINNERS. Senator, you raised a good point. You are quite correct. Some of the problems the Space Agency faced started long before the Challenger accident. There's been a very gradual but steady decrease in the funding of our research base, our flight programs, our institutional base. We do need to bring that back. And the budget we submitted, we think, starts us back on the path. I believe we do need the focus of a long-range goal, and that is where the President's new space policy is leading us. Now it commits to the goal of expansion of humans into the solar system. It does not make a decision yet to implement that.

We are on a path, as Mr. Povinelli was stating, to new technology, so that about three years from now, the country can make a decision as to what path to take on this very visible, highly-focused goal. At the same time, we do need to be sure that we don't neglect the rest of our program.

It does take a commitment. It takes the commitment of you people, the Congress, and the President to keep a strong, vigorous Space Program. We are doing what we can to bring that focus to it, to bring it to your attention. Do you, the Congress, the country, do you want a good, vigorous Space Program? If your answer is no, let us not try to fool ourselves or you to believe that we can conduct this very broad based program. We can't do it. It does require the finances. If we cannot, for whatever reason, put those finances in, we should not commit to major endeavors.

Senator KASSEBAUM. Maybe we should mention the 1989 budget request. It is $11.5 billion, I believe.

Dr. HINNERS. That's correct.

Senator KASSEBAUM. Which is a $2 and one-half billion increase that the President has requested. This request is a substantial increase, as a matter of fact.

I would have to say, as a member of the Commerce Committee, that I think it is going to be difficult to, at this point, find that money because it will have to come out of something else. I think our aeronautics and space programs are very important. But I think, as you say, Dr. Hinners, the public has to believe it is important, has to sense that we are no longer on the cutting edge of technology and development and that we are rapidly falling behind many other countries. The public must believe that leadership in these programs is important to us. Maybe either of you could spell out what happens on a daily basis in our lives that is a benefit from our space exploration and the related technologies. I think sometimes it is difficult to understand the practical applications of technologies that were developed for our aeronautics and space programs. Would you list a couple of those?

Mr. POVINELLI. I have one example that comes to my mind and that is the whole area of health care and miniaturization of systems that have taken place because of the Space Program that now enable numerous types of processes for health diagnostics that were not possible years ago.

The Space Program and the technology advancement in the Space Program, in my opinion, is clearly one of the wealth-producing investments that this Federal Government makes. There have been studies done over the years that have been reaffirmed just recently that indicate that investments in R&D have a minimum of fivefold increase or payback on every dollar that's invested. If there's going to be a future in this country of space technology in space, now is the time to continue that.

We look at the technologies that we're advancing in automation, robotics, materials, the humans-in-space aspect that we're proposing in Pathfinder, all of those have benefits back to Earth that we can imagine. They are not done specifically for those benefits. They're fallout benefits from the activities that we conduct for the space mission. One can imagine though that, by advancing automation and a number of those other technologies, improved air transportation systems will come about because of those. We can envision factories of the future that are more automated. We can envision hospitals of the future that have much better health care. Those are all indirect benefits, but I think ones that are real and founded in past experiences from the NASA Program.

Dr. HINNERS. If I could give you a research result that, first, I'd have to say has no connection with any benefit here. You are all familiar with the concerns about ozone and potential destruction of the ozone by the gases that get into the atmosphere, something call freons. Back in the late 1960's, NASA planetary astronomers and the university community also, were studying Venus, the atmosphere of Venus. They found evidence of chlorine in the atmosphere of Venus, started studying the chemistry of the chlorine in the atmosphere. In the early 1970's, one of those scientists said chlorine

is going into the Earth's atmosphere, what does it do. That started the whole chain of events of looking at the chemistry of chlorine in the Earth's atmosphere and its connection with potential destruction of the ozone layer. So, an unconnected research result found its way rather rapidly actually into, you could say, a very practical application of what's happening to our own atmosphere. The research provides the foundation of knowledge from which eventually any and all applications will flow.

Senator KASSEBAUM. I just have had handed to me a list of some of the spinoff applications of NASA-developed technology. This includes a hearing aid and pacemakers, both of which have benefited from some of the NASA-developed technology. I think that the last issue of NASA's technology spinoffs indicates that there are 30,000 spinoffs, which may be a surprise to many of us. In addition, satellites and the communication industry have benefited, I would think, enormously from much of the work that NASA has done in that area.

Dr. HINNERS. The remote sensing, the ability to look at our agricultural lands, to understand what's happening to our crops in near real time is something that came out of the Research Program.

Senator KASSEBAUM. Let me ask you what you think about a joint program with the Soviets.

Dr. HINNERS. That's got a lot of discussion recently. We have been increasing our cooperation with the Soviets. We have a joint working group now with the Soviets in our Planetary Program and our Science Program. We're going slowly. We believe there's benefit through cooperation. We understand the politics that get involved in both sides, the commitment necessary to conduct long-term research. So, we are taking a very methodical, step-wise approach. Initially with data exchanges, next potentially with exchanging experiements and flying on each others spacecrafts. People talk of the eventual possible joint U.S./Soviet mission to Mars with people. It's something to think about. We are clearly not in any position to commit to such a mission for ourselves or jointly, but something to think about. And I, personally speaking, think it would be wonderful if we could get the world's people working together on exploration rather than spending the trillion dollars we do to defend ourselves against each other. So, I'm hopeful but cautious. Cautiously optimistic I would say.

Senator KASSEBAUM. I mentioned the Soviets, but of course there's the European Space Agency which is a vitally functioning force in space.

Dr. HINNERS. Our Shuttle Program, our Space Station Program and many of our science programs already involve significant cooperation with the European Space Agency, with Japan, with Canada, which provided the remote manipulator for the Shuttle and will do so on the Space Station. Clearly, there are tremendous benefits to this cooperation. It's economical to share some of the costs of space exploration, but also we find it is good to get our countries working together, talking together, sharing the results of space exploration. So, there is a tremendous benefit in it.

Senator KASSEBAUM. Well, I know everybody here probably already knows, but for those who might not have been listening, the

Soviets have a manned space station, the Mir Station. Recently, the Department of Commerce has approved the license to a private company in the United States to conduct experiments, pharmaceutical experiments, I believe, on the Soviet Space Station. That shows again, I think, where we should be cognizant as a public of the benefits of a Space Station and that it will be the late 1990's before we can ever hope to achieve that realization. Is that not correct?

Dr. HINNERS. That's correct. And while I do support cooperation, I guess I'm still enough of an American that I believe we ought to be up there providing the leadership in space exploration. Damnation, I want to see the U.S. out there leading.

Senator KASSEBAUM. Mr. Povinelli, let me ask you, there's been a lot of speculation on whether the ISF, the Industrial Space Facility, which is a smaller commercially-developed space module, could operate as an interim space station until the larger NASA-space station is completed. Furthermore, I understand that between $400 and $700 million would be targeted in the administration's future NASA budget requests for this ISF. Do you believe an Industrial Space Facility would be in any way detrimental to, or would undermine or delay the deployment of NASA's permanently the manned space station?

Mr. POVINELLI. My responsibilities are not on the Space Station Program, but let me comment from my own perspective that I think if the funding is available, that certainly it would not delay the NASA Space Station at all. The Technology Program would use whatever type of facility is in space, depending on its capabilities, to do the kind of experimentation that I referred to, to do not only science experiments which is where NASA has done a lot of its effort in the past, but also to do technology and engineering experiments where required. This facility could be the Shuttle, as in the past, or a revitalized Shuttle and eventually the U.S. Space Station. But if other platforms are there, if they were met by what we needed, would be used as well if they met our requirements.

Senator KASSEBAUM. Let me ask you further, what are some of the aerospace technologies that we haven't developed as fully as we should and what are we doing about that? What would you consider a first priority?

Mr. POVINELLI. OK. A number of the technologies that I mentioned in my statement in space technology are being addressed by the CSTI and in the Pathfinder Programs in first getting us into low-Earth orbit and operating efficiently there and then looking out beyond that.

In aeronautics, as you mentioned a concern about the state of the budget and the funding available in aeronautics, there are many needs in the Aeronautics Program as well. The President's budget in Fiscal Year 1989 asks for a substantial growth in the Aeronautics Program to support areas of advanced composite materials, advanced propulsion systems, and aviation safety and automation. These are the key areas that we are seeking today.

We also, very appropriately and responsibly I believe, do evaluate our program on a continual basis with advisors and look for areas that need to be improved, and those are the kinds of areas that we roll the program over into so to speak. We decline the

areas that are not so productive or so needed and move into other areas that are.

Senator KASSEBAUM. I'm very pleased to see the focus on CSTI and the Pathfinder. I think these programs will return us to the cutting edge of technology—an initiative that was NASA's early hallmark. These technologies, development programs have been very successful in providing the impetus for the private sector to pick up and develop further the technologies. Furthermore, NASA's technology development programs have helped form the partnerships which I think are important, between NASA and the universities and the private sector.

But in all honesty, let me say that I think the President's National Space Policy is rather broad and you can find almost anything in it, to a certain extent. I'm sure you were pleased because it does provide some direction, but I wonder again if it is enough of a focus to really excite the kind of public support that you talked about earlier, Dr. Hinners. Is this policy adequate to generate the support needed for our space initiative of the future?

Dr. HINNERS. Senator, I think that remains to be seen. You're correct in that even the budget this year is not what it eventually will take to support this broad based, strong, Civil Space Program leadership. And in fact, two to three years from now that $11.5 billion budget, just with what is presently committed to, will grow to about 14. That is without having made any decision on where we go with these space ventures, back to the Moon or on to Mars. I believe it will prepare us to make those decisions. I am indeed happy with this budget, and I think it does get us on a start back on track. We have to keep that momentum going now into the next administration, whoever that is.

Senator KASSEBAUM. Well, that's providing you get that budget.

Dr. HINNERS. We're going to get it.

Senator KASSEBAUM. It's just interesting, I think, to note that in 1961, NASA's budget was .87 percent of the federal budget. Yet in 1989, the proposed budget request is only .93 percent of the total federal budget. That is not much of a change. There, of course, were years where it was a much higher percentage, almost 4 percent, when we were in the middle of the Apollo Program and there was a major focus on the space program. Now, however, we are back to what I think is an important rebuilding phase. I very much appreciate your coming here and helping us start to answer some of the questions and generate some of the interest that I think is important.

I've been speaking the last couple of days around Kansas and asking audiences if they really are prepared to support with tax dollars some of these initiatives, and I think that this involvement is going to be terribly important to gather that support. In addition, I want to thank you for making available the Aero Space Mobile at Meade Junior High. I think there is about a two year waiting list for this presentation, and it provides a unique opportunity for students in this area. I would also like to say that we are very fortunate in Kansas to have the Cosmosphere in Hutchinson which does a lot, for adults as well as for children, and I think it is an exciting realization of the potential that space offers. Thank you very much.

Dr. HINNERS. Thank you, Senator.

Mr. POVINELLI. Thank you.

Senator KASSEBAUM. Our next panel is Mr. Wendell Mohling, Ambassador to the Teacher in Space Program, from Shawnee Mission, Kansas; and Mr. Barry Schartz, who is Ambassador to the Teacher in Space Program from Goddard High School.

Let me just say for a minute before they speak what an important role, again, that teachers have. Dr. Hinners mentioned the importance of education in his testimony. These two teachers bring a lot of excitement to the classroom and dedication to the program, and it is a special pleasure to welcome you both here today. May I also say that I hope everybody can summarize their testimony and keep it under 5 minutes, so that we can keep the hearing schedule on track.

Welcome. Are you going first, Mr. Mohling?

STATEMENT OF WENDELL MOHLING, AMBASSADOR TO THE TEACHER IN SPACE PROGRAM, SHAWNEE MISSION NORTHWEST HIGH SCHOOL

Mr. MOHLING. Thank you. Thank you, Senator, and distinguished guests, and fellow citizens. It's a great pleasure for me to have an opportunity to be here with you this morning and to share my experiences, my interests and my concerns relevant to the activities of the subcommittee.

Three years ago, I completed an application that was to have a profound effect on my life. I applied as a candidate for the Teacher in Space Program sponsored by NASA. Although my application was accompanied by lots of hopes and lots of dreams, never did I imagine the impact my application would have on my future, nor the historical effect of this creative program.

As a career teacher, I was provided with an opportunity to dream, to plan, and to teach. An opportunity that I, nor none of the 11,000 other applicants, could put aside. The application certainly proved to be a challenging homework assignment. It caused me to do what every good lesson should do, to think.

Many of my thoughts were summarized in the project proposal requested in the application. Combining my communication skills as a teacher and my interest and talents as a photographer, I proposed a multimedia project which would help me share my space experience. As I thought about this opportunity, it caused me to reflect on my own educational background, including my schooling as a farm lad in Nebraska, and I had a title for my future presentation, "One Room School to One Earth Classroom."

Within the short history of our Space Program, we have seen the development of a feeling of oneness about the Earth comparable to my childhood feelings of the oneness felt with my classmates in that rural, one room school. Furthermore, the technological advances made possible by the energetic Space Program have allowed the opportunity for a teacher to expand his horizons from a "One Room School to One Earth Classroom."

As many of us have lived through the entire history of our Space Program and have witnessed the remarkable achievements, it is perhaps understandable that we need to take time to reflect on the

significance of our technological achievement. This reflection gives us an important perspective of where we have been and where we are going. NASA's Teacher in Space Program allowed me to think, "One Room School to one Earth Classroom."

I completed my homework, and a few months later gathered with the other finalists throughout the Nation in Washington. I am proud to be a teacher, but during that week in Washington, NASA made it easier to be proud. Named "Ambassadors of the Space Program," we were treated with the best in teacher fare, workshops and a flight bag bulging full of goodies to take back home to share with our students.

And share we have. During the 1985–86 school year, I gave 65 presentations to 13,000 plus citizens. In 1986–87 an additional 85 programs for 7,800. And all of this was in addition to full-time teaching responsibilities with limited leave time available. I didn't do the presentations because I was required to, I did them because I wanted to. Teachers love to share what they learn.

With a somewhat more flexible schedule this year, made possible by the U.S Office of Education, Christa McAuliffe Fellowship, I have already managed an additional 90 presentations to 18,000 more. I will continue to squeeze in as many programs as I possibly can into my busy doctoral residency schedule.

Why have I, and many of the other Teacher in Space finalists, been willing to serve in this role as Ambassadors? The answer is intertwined with our reasons for selecting teaching as our profession. It is true we love to learn and we love to share the excitement that we have about learning anything new.

I believe that there are two other contributing factors to the answers sought here. First of all, NASA provided an opportunity and a support base through the Educational Affairs Division that, in my opinion, is unequaled in its sensitivity to the needs of educators. Dr. Hinners reviewed a number of the services provided by NASA and we can discuss those later.

I utilized many of those services and I can generalize that the quality of products and mode of dissemination has been outstanding in meeting the needs of this educator.

Furthermore, the fact that a classroom teacher can be certified to check out "Moon rocks" to enhance a lesson speaks highly of the established commitment to education and civilian involvement that NASA provides.

The other factor contributing to the willingness we have to share our excitement with others has been the fact that we have had a most receptive audience. If the pulse that I felt from those 40,000 in my audiences is any indicator, there's a strong National commitment to the challenging Space Program that deserves to be tested. People of all ages are interested in space. Space provides a motivating team that sets the "I want to learn more . . .," spark into action.

Those important human strokes, warm applause and handshake, an inspirational question or comment, or a second grader's artistic interpretation, are the only payoffs required to stimulate a teacher to set up a slide program one more time.

So, as an Ambassador, I will continue doing slide programs, with themes such as "The Right Stuff—A Good Education," for elemen-

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tary school assembly programs. I will give more demonstrations on the physics of flight for high school classes and discuss the importance of the Space Station with a middle schooler. I will teach more teachers the interdisciplinary aspects of the Space Program and share with them in workshops or classes methods of incorporating toys in space, model rocketry, or habitat module design into existing curricula. And I will review with my community members the cultural, scientific and economic implications of a strong Space Program.

As a nation, we celebrated the achievement of a National commitment and goal when our Apollo astronauts set foot on the surface of the Moon. We set a lofty goal and worked hard to meet the task and enjoyed a measured success. The parallel in education is obvious. Helping others to set and reach their goals is embedded in the daily activities of every teacher, and we share in the obvious excitement of a goal achieved. What is not so obvious are all of the learning steps along the way, without which the goal would not have been reached. These steps provide further impetus in finding new goals and solving new problems. In other words, setting foot on the Moon was important, but it was a small achievement compared to getting there and returning home.

The importance of the journey needs to be remembered as we seek goals in education, in science and technology, and in space. It is my contention that the entire space budget would have been worthwhile even if we would not have launched most of the hardware since it provided the research and development money to keep this Nation on the cutting edge of achievement.

As a nation, we also mourn and pay tribute to those who lose their lives helping others to seek new horizons. As an Ambassador, I shared the Challenger tragedy with my students and colleagues, and I gained inspiration as students launched balloons in memorial tribute "to the seven team members of the Challenger who taught us what it means to be a pioneer and why it is important for us to follow."

Just as we evaluate, adjust, and go forward with an active Space Program, achieving new horizons in science, technology, and society by maximizing the gains already made, so we must in education.

We must seek new and efficient methods to incorporate the knowledge and technology gains into the classroom. Space-age tools such as computer, videodisc, and satellite technologies need to be more quickly and easily available to the teacher. Teachers need further access to training programs and time to incorporate these tools in lessons that will continue to challenge the next generation of pioneers. Leadership provided by members of this committee and a continued interest in support of the education dimensions of our space program can help to provide the necessary opportunities for our students. This is of utmost importance if we expect to gain and maintain the leadership and momentum in high technology research and development into the 21st Century.

As we open the space frontier, we will recognize further the potential of human thought and endeavor. We will realize that the remaining frontier is the human mind, and it will always remain a frontier if it is inspired and encouraged to do so.

Teachers remain dedicated to this task and are most willing to work with you as we reach out to touch the future.

I would also add in closing, and I thought I would bring it to the Committee's attention, that I noted what appears to be an extra room on the latest drawing that I've seen of the Space Station. With a little bit of teacher modification, it looks just perfect for my "One Earth Classroom."

Senator KASSEBAUM. Thank you. I would just like to add that I first met Mr. Mohling and his wife when they came to Washington several years ago to lobby me on an environmental issue.

Mr. MOHLING. That's right.

Senator KASSEBAUM. They have been actively engaged in many community concerns as well as National concerns, and I think both he and Mr. Schartz typify the very best in education. Mr. Schartz, from Goddard High School.

STATEMENT OF BARRY SCHARTZ, AMBASSADOR TO THE TEACHER IN SPACE PROGRAM, GODDARD HIGH SCHOOL

Mr. SCHARTZ. Thank you, Senator, and other distinguished members that are present today. I've been honored to be a part of the Teacher in Space Program and the Ambassador team for NASA, and I found it kind of difficult to summarize some of the things that I've done. I think instead of reading through my prepared statement, I will just highlight a few items. As far as some of the things, Wendell has, I think, done a very good job of summarizing those. People can read my prepared statement at their leisure.

I would like to point out that the presentations that I have given, I've not given as many as Wendell, have numbered about 60. Most of those occurred in the first year to some approximately 6,700 individuals involved. I have driven, I don't have a mileage figure, but I know that the distance that I drove for the furthest presentation was over 700 miles, plus I taught two hours that morning. I was at school this morning. So, my students are a priority to me. And as Wendell said, the things that we do in the Teacher in Space Education Program are really secondary as far as the other things that we're doing.

I think there are three areas that I've concentrated as far as presentations, and I talk about those in my testimony. Number one is to visit with the students and to share some of the techniques, the experiences, and the knowledge that I have about space education and try and get them enthused about the things that they're doing. If I may, just for example, this is one of the toys that has flown on the Shuttle. Not this one, but if you hand this to a first grader or a high school senior in a physics class and you let them work with it a little bit and then you start asking questions. Well, why does it work this way? We have a magnet and gravity and so on and so forth, what happens if we're in the Shuttle environment. Pretty soon they come up and say, well, there's no gravity. Well, 75 percent of the college engineers that are graduated from college today, I've heard this figure, I don't know how good it is, but 75 percent of them can't explain weightlessness. All of a sudden you get into some other things besides the things that are taught in the classroom. But these are thought-provoking things that we can

show to the students. Then we have videotapes that NASA has provided us that actually show what happens.

I have numbers of other things with me as playing jacks, magnetic marbles. Can you do those things in space? Those are thought-provoking questions. You get the students to think about those kinds of things and you get them interested in learning. Once you have them interested in learning, then the teacher can teach to them. I think that's very important. I talk about that in my testimony.

The other thing that I try to do, and I know that Wendell and the other ambassadors have done, is to work with teachers, showing the kinds of materials available from NASA. I brought samples. If I might, this is a sample of some of the things that are available. This is just a sampling, everything from biomedical research data from Skylab to space physiology, to mathematics in space, to things on art. NASA has interdisciplinary things. I try to tell teachers that, number one, we don't have programs in NASA that are just science based. It really goes beyond the curriculum. In my application for the Teacher in Space Program, I talked about the fact that we could look back from the Shuttle and see the Earth as the "Spaceship Earth." A place that we're going to have to learn to live as a group. So we're talking about sociology, we're talking about psychology, we're talking about all kinds of different curricular areas.

The other thing that I try to do, and I know the other ambassadors try to do it, is to get out to the general public, "what is NASA about." We give presentations, whether it's the Optimist Club, the Lyons Club, some of the fraternities and sorority groups that we have, on the kinds of things that NASA is doing. The kinds of things that we're trying to do in education. I think it's important for the Committee to understand the fact that really the future of this country is going to be determined by how well we are educating the kids today, and I see the Teacher in Space Program as an excellent investment as far as cost effectiveness. The cost effectiveness of this program is probably greater than most of the other programs that the government has, because the Teacher in Space group, the NASA Ambassadors, have done a lot of this on our own time, our own money. NASA has trained us, they have provided materials for us, then we have taken it and ran, really ran with the ball.

I appreciate the chance to testify today, and I really believe in the future of this country and the future as far as educating children today. Thank you.

[The statement follows:]

STATEMENT OF BARRY L. SCHARTZ, KANSAS TEACHER IN SPACE

Senator Kassebaum and other distinguished members of the subcommittee, let me first of all thank you for the opportunity to make my remarks to this body. I am honored to have been a part of the NASA Teacher in Space Program and to be a member of the NASA Space Ambassador Team. It has been difficult to try to summarize my activities in both roles because of the many and varied activities that I have been involved in and continue to be involved.

I would like to point out that the Teacher in Space Program has had a very strong impact on me as a professional. My commitment to education, not only to the students in my classroom, but to all students has been strenghtened. To this end, I

made an early commitment to reach as many students and teachers before the 51-L mission as I could in order to inform them about what NASA was doing for education and what was available to them.

Students and teachers were and still are excited about what NASA is doing, and I see that excitement being turned into positive learning opportunities.

My activities as a NASA Space Ambassador can be grouped into four major catagories; presentations to students, to teachers, to the general public and miscellaneous activities. Over the past two years, that has meant over sixty presentations given to approximately 6,700 individuals, almost half of who were students K-12. This does not include any television or news media coverage. These numbers do not represent as many presentations as some Space Ambassadors have made, but they do represent a good start in Kansas. I would like ot point out that during this time, I remained involved in may other activities, in and out of the teaching profession.

The student presentations that I give have convered numbers of topics, from paper airplanes to future space travel to setting goals. The topics of my presentations are designed to fit the needs and levels of the students. I am hopeful that this is demonstrated in part by the materials and display items that I have brought with me today. Nearly all of the materials and display items that I use are generated by NASA, maybe not directly, but indirectly, through workshops or conferences. Items such as video tapes, pictures, posters, special topic publications, other publications as listed in "NASA Educational Publications (PAM-101/7-87)", as well as other material that NASA has distributed to the Space Ambassadors and other educators on the mailing list, have been invaluable resources.

I am often asked to give presentations on a specific topic of for a specific group. For a physics or chemistry class, the emphasis might be on how the space environment affects physical principles. Life science classes want to know more about the space environment effects on human physiology and life in general. Lunar and planetary geology might be described to earth/space science classes, and younger school groups are fascinated by more general topics such as life aboard the shuttle, its bathroom, kitchen, etc. The international student groups are very interested to learn about our Space program. Whether the presentations are on the history of space exploration, careers in aerospace or individual goal setting, the level of attention remains high. No matter if the audience is a group of second graders, high school seniors or senior citizens, attention seems easy to keep, especially when I am doing some of the demonstrations from NASA workshops.

Once the attention of the student is gained, real educaton can happen. This "space stuff" that NASA deals with not only gets kid's attention—it gets them excited. When I ask students how many would like to walk on the moon, most hands "shoot" up. The excitement builds as teachers capitalize on this interest in their classrooms.

The effective channeling of student excitment can best be accomplished by an excited and well trained teacher. I have given a number of teacher workshops dealing with the general topic of space, similar to the general topic presentations that I give students; but including information on what resources NASA has available for teachers, and how these materials may be incorporated into the curriculum and used in their classrooms. I have a number of items with me today to give you an idea of the quality and variety available.

I give teachers information about the Aerospace Educations Services Project (AESP), which includes the space mobil. I remember so well, some years ago, the impression a high school NASA presentation left with me. NASA also has film catalogs and bibliographies, including a new publication, "Software for Aerospace Education", which I have on exhibit today.

The AESP staff has shared their expertise with the Space Ambassadors. Elementary and secondary teachers can also share this and other training in the NASA Education Workshops for Elementary School Teachers (NEWEST) and NASA Education Workshops for Math and Science Teachers (NEWMAST) programs. I do encourage teachers to apply.

A NASA teacher resource room in Kansas is soon to become a reality. Many teachers will discover the variety of items available and how to be inventive in their use. The Resource Room is to be placed on the Hutchinson Community College Campus in close proximity to the Kansas Cosmosphere, another excellent teacher resource. Teachers will find that NASA programs and materials are enhanced by the Kansas Cosmosphere.

Often overlooked is NASA's efforts in all curricular areas. While most items are science related, NASA has materials available in art (Space Student Involvement Project), social sciences (Social Sciences and Space Exploration), journalism (Space Science Student Involvement Project), math (Space Mathematics: a resource for sec-

ondary teachers), etc. In teacher workshops, I stress the interdisciplinary use of NASA's materials and space education, emphasizing that these materials can be incorporated into the existing curriculum, instead of having to be taught separately when the day is "already full".

Many of NASA's workshop materials contain classroom activities, such as word search puzzles, student hands on activities, scrabble puzzles, etc. A good example would be the Lunar Geology Information and Activities. Again, I have a number of examples with me today.

There are more NASA education programs that are available for students and teachers at all levels, that I touch on in teacher workshops. A good reference of these programs is the NASA publication "Educational Affairs Plan: A Five-Year Strategy FY 1988–1992". These programs do work!

Another role of the Space Ambassador has been to involve the general public. I share my experiences and give a general overview of the space program and its benefits. I also talk on the educational benefits. The general public is as interested in this "space stuff" as elementary students.

Other activities have included getting NASA traveling exhibits at state and regional conventions, being on a number of television and radio shows, and involvement in various memorial services.

The activities of the other Space Ambassadors have been many and varied. Some have had release time to work in various capacities: NASA, State Departments of Education, etc. Others, like me, have had to work around their teaching schedule.

As the Space Ambassadors have shared their activities and ideas, the programs has strengthened. For such a cost effective program, the real winners are the children of these country.

Senator KASSEBAUM. Thank you very much, Mr. Schartz. I know I need to go back to the classroom. What you are doing is terribly interesting. Are those some models that you use, too, behind you?

Mr. SCHARTZ. Yes, behind me. I take these models of the Challenger that I have with me. This is a model of the Challenger, and it does fit up with the gantry here. But whenever you take this model in to give a presentation it creates interest. I've given presentations to as large as 450 in the audience. I think I had a group of third, fourth and fifth graders at El Dorado a few years ago, there was 450 of them bused into a central location. As you start talking, using models, you get them—the students—up and have them do things like this; they become involved in the presentation. All of a sudden their interest becomes involved. You can lay a log on the fire but it needs a little kindling to get it to burn. The model is kind of the kindling.

Senator KASSEBAUM. Let me ask both of you, because we read a lot about the fact that our students are behind, particularly in the disciplines of math and science, students around the world, particularly Asia. What should we do to enhance our education system, to become more competitive particularly in those fields? Do you have some suggestions?

Mr. MOHLING. I'd like to respond to that. I really don't know the status in some other countries, but I can discuss what I see going on in the classrooms and what I see developing.

One, as Barry mentioned as well, is we go out and talk to students. I think using space as a grabber, as an interest vehicle is what we're using. But the kids are excited about learning and space is simply that interest motivator. But we are also stimulating many scientists and engineers, and I have worked with a number of students and I find quality students. It's hard for me to imagine better students. I've had some good ones.

But sometimes we're a little lacking in the materials that we would like to provide them. I mentioned some of the space-age tools

that we have available, satellite videoconferencing, computer technologies, videodisc applications, and various kinds of resource materials that are available, really, to the public and should be more readily available to classroom teachers. Unfortunately, it is oftentimes too many years too late that I had some students slip by without having had a chance to use those tools. Teachers need to have the opportunity to spend time in training and working with these tools as well.

When I went through my first teacher training, I didn't know anything about computers. In fact, we were talking today "about what's a slide rule?" Kids are asking today because they have not used them. Things have changed very, very rapidly, and it changes for the teacher, too, so we have to make current tools available and use them.

I think that one of the bright things I see happening to NASA's Education Division is they're utilizing some of those in their demonstrations out in the field and perhaps that can provide some direct in-service to teachers.

I guess the idea of just simply doing more with what we've already got isn't what we need in education. We are going to have to reevaluate. The students today are demanding better curriculum materials. That requires teachers to have time to develop those materials. I think increasing all aspects of teacher involvement in education is vitally important to the success of our students in the future.

Senator KASSEBAUM. Mr. Schartz, do you have anything additional?

Mr. SCHARTZ. Well, I find it interesting that a corporation or even NASA or somebody develops these materials or a new curriculum that they want to add to the school when the school day is already full. What's a teacher to do with that?

Number one, they have to be trained, and I think one help has been NASA. Whenever you look at NASA's five-year fiscal plan as far as the educational support they're giving, giving teacher training, going into the teacher education institutions and helping work there, I think that has a lot of merit as far as the kinds of things that we're going to be able to do.

I think that the societal pressures on education, and I can't talk about the societal pressures on other educational systems in foreign countries, have an awful lot to dictate what happens. If Johnny or Mary has to have a job after school, then school may suffer. I try to tell my students this is your job. This is what's going to lay the groundwork for the rest of your future. We've got to decide, as a society, that education is important. Number two, if we need the funds, and we're going to need them, school boards, working under the same kinds of budget constraints that Congress does, will need to make hard decisions—decisions that we want the best education for our kids.

I find it interesting about my son in the second grade. By the time he graduates from high school, the information is supposed to double 37 times. He's going to change jobs, a predicted seven times in his lifetime. What kind of education do these kids need? Those are some serious questions that we need to talk about.

Senator KASSEBAUM. You are both high school teachers. Do you feel that students coming through to high school are getting the preparation, in the basics of reading and writing, that is still essential even with today's emphasis on computers? Are those students able to critically question if they have an interest that can be developed in science and math? Are students coming to you as prepared as they should be?

Mr. MOHLING. I would have to say this, that I'm seeing students coming to the high school level today who are much better prepared than they were a few years ago. I think that we have made some important strides in education. I think that the focus in this country on education, the emphasis that we placed in many schools in terms of doing a better job with the curriculum, additional teacher training, and so forth, is paying off.

I certainly would have to say that even though my one room school training was very, very good, the questions and the questioning skills and the writing skills of many of the students that I see coming to high school today far exceed my classmates and my own abilities a few years ago. That does not mean to say that we are doing enough, because as Barry mentioned, the demands and the expectations for the students that we have in our classrooms today are much different. That is why we need to have access to information bases and so forth. You know, we could memorize the entire book in the old one room school. My high school students today will learn more about genetics than a Ph.D. in genetics did when I was in high school. So, we're expecting them to get their "Master's and Doctor's" at the high school level, and we sometimes forget the wealth of information available.

I find one other thing that's interesting, I think that the spinoff of interest in our Space Program and in education is also occurring with our students. I have found out as I've gone out and talked to schools and the students that not only are there more students than ever that want to be part of the Space Program, there are also more students than ever that want to be teachers. In my high school last year in a senior survey, becoming a teacher ranked number two in an interest survey.

Senator KASSEBAUM. That is good news.

Mr. MOHLING. That was surprising news, because I can remember a few years back when nobody, we're talking classes of 600, nobody wanted to be a teacher. So, I think that the increased focus is paying off.

Senator KASSEBAUM. Well, thank you both very much. I think we should be very proud of having teachers like you in Kansas and those who are engaged as Ambassadors in Space. Thank you very much.

The next panel will give us some expert advice. We have today some Kansas University professors who are actively engaged in the cutting edge of technology. It's a pleasure to welcome Dr. William Wentz, who is Director of the Institute for Aviation Research at Wichita State University; and Dr. Jan Roskam, Professor of Aerospace Engineering, University of Kansas; and Dr. Brian Spooner, Professor of Biology, Kansas State University. Welcome. Dr. Wentz, do you want to go first since you are at this end of the table?

STATEMENT OF DR. WILLIAM WENTZ, DIRECTOR, INSTITUTE FOR AVIATION RESEARCH, WICHITA STATE UNIVERSITY

Dr. WENTZ. Thank you, Senator Kassebaum. I am honored to have been invited to appear this morning. I would like to say at the beginning I think, and on behalf of my colleagues here, Mr. Schartz referred to the difficulty of college graduates in understanding zero-gravity conditions, and I'm sure that he and my colleagues here would agree that they obviously are not graduates of the Kansas educational system.

Our remarks this morning will pertain to maintaining high technology and development by enhancing NASA-university relationships. The technologies required to support space research and operations have always been rooted in the field of aeronautics. The design and development of airplanes has produced most of the technologies required for space. The Space Shuttle has inaugurated an era of space travel in which many of the characteristics of the airplane are integrated with those of the spacecraft. The proposed Aero-Space Plane type vehicle will further enhance space operations and have many of these characteristics. We look forward to the resumption of the Shuttle flights.

The proposed Space Station offers a laboratory which is certain to produce many benefits, including the technological gains associated with development of the laboratory as well as the knowledge gained from experiments which will be possible in the long term zero-gravity environment.

The National Aeronautics and Space Administration and its predecessor, the National Advisory Committee for Aeronautics, have a long history of providing the technology base for this Nation's aviation and space industries. These agencies have traditionally recognized the value of joint relationships with universities in research.

I'd like to tell you a little bit about some of the research at Wichita State University. Dr. Armstrong stole my first theme when he referred to our history of beginning in the 1930's. I'd just mention that Mr. Duane Wallace, Chief Executive, or former Chief Executive Officer at Cessna Aircraft Company developed the famous Cessna Airmaster in a wind tunnel on this campus.

In the 1940's and 1950's, the Beech wind tunnel was established here, and we conducted research for the Office of Naval Research on blowing boundary layer control and shrouded propellers.

In the 1960's, we began our research relationships with NASA, and we in this time period were doing low speed delta wing research which was thought to be applied to the Supersonic Transport, which of course was not built in this country, but in fact, some of that research was used on the Space Shuttle, it's used currently for the F-16, F-18, and other new fighter aircraft currently being designed.

In the 1970's, we worked with NASA in developing general aviation airfoils using computer design techniques, and these were developed and tested jointly with NASA and in our laboratories. A number of these have been applied to general aviation aircraft today.

The 1980's, we've been involved with wind turbine research, laminar flow, deicing, and star atmospheres. I'd like to tell you just a little bit about some of those. The Natural Laminar Flow Program is one we're especially proud of and it points up something we think is very valuable about our research relationships. It's a NASA, Wichita State University, Cessna and Boeing project. We believe this industry-university-NASA relationship is very valuable.

Another program that we're involved in currently is Electro-Impulse-De-Icing. This is a truly revolutionary method for removal of ice from aircraft wings. This technology, when completed, has great potential for saving lives, aircraft, and fuel.

Atmospheres of stars. We're working with NASA through the Ames Research Center. We're using their supercomputer. One of our professors here is doing work studying the atmospheres of stars.

The 1990's and beyond, an increased commitment to research by Wichita State University. Under the leadership of President Warren Armstrong, Wichita State University established the Institute for Aviation Research two years ago. We started planning about four years ago. We are currently conducting research for the Army Research Office, the Federal Aviation Administration, and several joint programs sponsored by the Kansas Technologies Enterprise Corporation, and a variety of aerospace manufacturers. We have the tangible support of Boeing, Beech, Cessna, the City of Wichita, Sedgwick County, and the Kansas Regents in this enterprise.

Why conduct research in a university environment? I would like to cite some examples of how we think this will benefit. Efficient, shared use of expensive facilities: Research facilities are expensive. Our wind tunnels have been used for basic research supported by government programs, for specialized development programs for specific aircraft by the aerospace industry, and finally by university faculty and students for unsponsored research and for training in wind tunnel use. This combination: research, development, education, has provided the high utilization of these facilities at minimum cost and maximum benefit.

We believe this concept of shared use of expensive, special-purpose laboratories, equipment, and instrumentation has application to other laboratories. Specifically, we have developed new laboratories for flow visualization water tunnel, a shock and vibration laboratory, composite materials fabrication, composite structures laboratory, and icing laboratory. We are developing a dynamic test facility for crashworthiness, advanced materials laboratory, propulsion inlet research laboratory, and a stall-spin prevention flight simulator.

Interactions: University based research provides interaction among the disciplines and with nontechnical groups, improved capabilities to meet foreign competition. And one of the patterns for foreign competitors is a strong university-industry-government relationship.

Benefits of NASA-university research are cost benefits to the university to help us support the facilities. NASA faculty interactions, the scientific engineering exchanges are invaluable.

Graduate assistantships. Investment in education made by previous government programs which support graduate education is paying rich dividends. Graduates from Wichita State University's Science and Engineering Programs currently serve with every major NASA laboratory and with other government laboratories, with every major aerospace manufacturer, and with each of the military services. Many of our current engineering and science faculty at this university receive graduate school training through NASA or NSF fellowships. As a personal note, I received support for my doctoral studies through the NSF Science Faculty Fellowship Program, and I am extremely grateful for that support.

What are some of the problems and shortcomings of present NASA-university research? One, short-term commitment. Two, emphasis on computers rather than experiments. Three, a tendency to fund exploratory research and not fund development.

I've listed in my written testimony some characteristics of a successful research center for the 1990's and beyond, and we have listed these characteristics. We believe that our newly established Institute for Aviation and Research meets these criteria. And I'd like to talk just momentarily about the National Science Foundation University Centers Program. The Institute for Aviation and Research recently submitted a proposal for a planning grant for the NSF Science and Technology Center Program. We have learned that this entire program for STC/ERC is in jeopardy for the present year because of limited resources, large number of applicants.

I would also like to make a series of recommendations to this committee. Specifically, first, continued support of NASA's manned and unmanned Space Program. Second, increased support for NASA research related to aeronautics. Let's not forget the "A 'in NASA. Support for more joint university-industry-government research, increased support for graduate fellowships in the aerospace specialties, additional support for interdisciplinary research centers at universities. Sponsorship might be from more than one government agency, when appropriate. Finally, upgrading of experimental facilities of both the government and the universities, with particular emphasis on modernization of instrumentation.

Finally, we look forward to the challenges of the 1990's and the 21st Century. The leaders for that era are currently enrolled in our classrooms. We believe that with proper leadership from the Federal sector, and cooperation from the industrial and educational sectors, this Nation can and should retain its preeminence in aviation and space.

Thank you for the opportunity to be here.

[The statement follows:]

STATEMENT OF DR. WILLIAM H. WENTZ, JR., EXECUTIVE DIRECTOR, INSTITUTE FOR AVIATION RESEARCH, WICHITA STATE UNIVERSITY

INTRODUCTION -

Senator Kassebaum, members of the committee: I am pleased and honored that you have invited me to appear at this hearing. I have been involved in the aerospace industry for 33 years, and have been a university professor involved in NASA-sponsored research for most of the past 25 years. I am currently a Distinguished Professor of Aeronautical Engineering, and serve as Executive Director of the Institute for Aviation Research at Wichita State University. While my professional background has been primarily in aeronautics, the differences between aircraft and spacecraft are diminishing, and the underlying technologies are closely related.

RELATIONSHIP BETWEEN SPACE TECHNOLOGIES AND AERONAUTICS -

The technologies required to support space research and operations have always been rooted in the field of aeronautics. The design and development of airplanes has produced most of the technologies required for space. Any flight vehicle, whether it be airplane or spacecraft, has requirements for light weight structure, high performance from propulsion system, demanding environmental control for passengers and/or crew, and high precision requirements on navigation and control systems. The Space Shuttle has inaugurated an era of space travel in which many of the characteristics of the airplane are integrated with those of spacecraft. The proposed Aero-Space Plane type vehicle will further enhance space operations by permitting much more convention type takeoff, and will be able to land in a powered aircraft mode, allowing for go-around in case of a bad approach, and for a wider selection of landing sites. These capabilities will provide a new level of safety and flexibility to space and hyperosonic flight operations. The proposed Space Station offers

a laboratory which is certain to produce many benefits, including the technological gains associated with development of the laboratory as well as the knowledge gained from experiments which will be possible in the long term zero-gravity environment.

The National Aeronautics and Space Administration (NASA), and its predecessor, the National Advisory Committee for Aeronautics (NACA) have long history of providing the technology base for this nation's aviation and space industries. These agencies have traditionally recognized the value of joint relationships with universities in research.

HISTORY OF AEROSPACE RESEARCH AT WICHITA STATE UNIVERSITY -

The 1930's - Emergence of Aeronautical Engineering

Wichita State University has a rich history of research in aerospace education and research, dating from the 1930's when our first wind tunnel was constructed by faculty and students, including Mr. Dwayne Wallace, who later to become chief executive officer of Cessna Aircraft Company. The famous Cessna "Airmaster" and several other airplanes of the era were developed in this wind tunnel.

The 1940's and 1950's - Beech Wind Tunnel Established

In the late 1940's, the Walter Beech Memorial Wind Tunnel was constructed and placed in service at Wichita State University. Research in this time period was primarily sponsored by the Office of Naval Research, and the focus was to study and develop blowing boundary layer control to aid wings in producing additional lift at low flight speeds. This research data base is finding current application in the new X-wing helicopter, and for other fixed wing aircraft programs. Other research in this time period included development of shrouded propellers, which are currently attracting renewed interest for potential high-efficiency aircraft applications.

The 1960's - Low Speed Delta Wing Research

In the 1960's Wichita State University participated in research programs with NASA to develop an understanding of the behavior of delta wing airplanes at low speeds. It is interesting to note that this research was motivated by the Supersonic Transport program which was subsequently cancelled. The measurements of vortex flows associated with low speed flight of delta wings conducted in our wind tunnels in this era were used, however, by NASA and industry designers for developing the current supersonic fighter aircraft, such as the F-16 and F-18. This example is probably typical of the long lead time between research and application. These same wind tunnel results were used just last summer by an international group of researchers to check the

latest generation of computer programs being developed to predict the the characteristics of future airplanes.

The 1970's - General Aviation Airfoil Development

The decade of the 70's was marked at WSU by research and development of computer-designed airfoils especially suited for general aviation aircraft. The University worked closely with researchers at the NASA-Langley Research Center in the development of these airfoils, and the flap, spoilers and ailerons required for their ultimate application. These airfoils and control systems have been applied to a number of general aviation aircraft.

The 1980's - Wind Turbines, Laminar Flow, De-Icing and Star Atmospheres

Wind Turbine Research: During the present decade, WSU researchers have been involved in development of high performance wind turbines for power generation. This research has included improvement of computer methods for wind turbine analysis, development of the aerodynamic data base for wind turbine airfoil sections, development of advanced aerodynamic controls for wind turbines, and techniques for design of optimum wind turbine blade shapes. In addition, WSU researchers were responsible for small scale (wind tunnel) tests of wind turbines and control systems, and participation with researchers at NASA-Lewis Research Center and NASA-Langley Research Center in full-scale tests of wind turbine ailerons for power modulation and aerodynamic braking. This was the first wind turbine in the world to be controlled by ailerons, saving weight and cost.

Natural Laminar Flow: Laminar flow offers reduced drag, and therefore fuel savings. In a joint NASA-WSU-Cessna-Boeing program, advanced instrumentation for wind tunnel and flight tests was developed, and flight evaluation of NLF was conducted at low and high altitudes, and with straight and swept wings. Cessna has a new high performance airplane flying which uses this advanced laminar flow technology.

Electro-Impulse-De-Icing: EIDI is a truly revolutionary method for removal of ice from aircraft wings, in which small coils are imbedded inside the wing leading edge. When sequentially activated, these coils, properly located and sized, act like small hammers within the wing. This system causes the local exterior aircraft skin to flex, cracking the ice so that the airstream carries it away. This research has progressed steadily from concept to theory, and from bench tests to icing wind tunnel tests, and finally to full scale flight tests. This technology, when completed, has great potential for saving lives and aircraft. In addition, considerable fuel savings are possible, since current de-icing systems usually cause added drag due to the external boots required. This research has been sponsored by the NASA-Lewis Research Center. Unfortunately, continued funding for this program has been difficult to obtain, because the

activity is no longer viewed as fundamental research but rather as "development."

Atmospheres of Stars: The atmospheres of red giant stars are being studied by a team of scientists from NASA-Ames Research Center and several universities, including WSU. Access to the NASA Numerical Aerodynamic Simulation supercomputer is provided to university researchers on a cooperative basis to assist in this research.

The 1990's and Beyond - Increased Commitment to Research by The Wichita State University:

Under the leadership of President Warren Armstrong, Wichita State University established the Institute for Aviation Research just over two years ago. Since the Institute was established, support has been obtained from a variety of governmental and private resources. We are currently conducting research for the Army Research Office, the Federal Aviation Administration, and have several joint programs sponsored by the Kansas Technologies Enterprise Corporation (KTEC) and a variety of aerospace manufacturers. Sedgwick County and the City of Wichita also have supported the Institute through bond issuance to support our new laboratory, which is scheduled for construction beginning mid-1988. The Kansas Board of Regents has supported establishment of additional doctoral programs to complement the Institute. Thus the Institute is well prepared to participate in expanded research activities from the present into the 1990's and beyond.

BENEFITS OF CONDUCTING RESEARCH IN A UNIVERSITY ENVIRONMENT -

Conducting research in a university environment has a number of advantages. First, it provides access and participation of the best talents available. Second, it provides a neutral setting in which competing companies are more responsive to cooperative efforts. Third, it provides participation of students. This makes the operation very cost-effective, and provides the best possible training for students. Fourth, universities are well-equipped to provide for rapid dissementation of research results through publications, seminars, etc. Finally, universities are an ideal location for sophisticated research facilities and instrumentation. I would like to elaborate on this last point by describing our experiences at Wichita State.

Efficient, Shared Use of Expensive Facilities:

Our wind tunnels have been used for basic research supported by government sponsored programs, for specialized development programs for specific aircraft sponsored by aerospace manufacturers, and finally by university faculty and students for unsponsored research and for training in wind tunnel use. This combination of functions has served the university, industry and government admirably during the past four decades. The federal

and industry research projects provide the funding required for sustaining the facility, and the availability of the facility for graduate and undergraduate student training provides the highest caliber educational experience for the students. Further, operation of laboratories in the university environment provides for high utilization of these expensive facilities and equipment, by a maximum number of researchers from a variety of disciplines.

We believe that this concept of sharing expensive, special-purpose laboratories, equipment and instrumentation has application to other laboratories. As our research capabilities expand, we will offer this service in other areas. Specifically, we have a new flow measurement wind tunnel and a new flow visualization water tunnel, shock and vibration laboratory, composite fabrication and composite structures laboratories, and an icing laboratory. We are developing a dynamic test facility for crashworthiness testing, advanced materials laboratory with several electron microscopes, propulsion inlet research test rig, and stall-spin prevention flight simulator.

Interaction Among Disciplines, and With Non-Technical Groups:

We are commited to fostering integrated research activities which will be truly interdisciplinary. Interdisciplinary research is essential in many situations, since the nature of many technical systems is that they involve human interaction. Furthermore, emerging technologies do not fit "traditional" disciplinary molds. Composite structures may involve a polymer chemist, material scientist, structural designer, and fabrication specialist. Laboratories with a unified theme, such as the Institute for Aviation Research, offer an appropriate environment for such interdisciplinary groups to function efficiently. In addition, our Institute is involved in management issues related to aviation, and provides special non-credit training and seminars related to aviation. Computer Aided Design and Computer Aided Manufacturing are areas of critical need in the aviation industry in which our Institute has capabilities.

Improved Capability to Meet Foreign Competition:

Both European and Asiatic aerospace competitors rely heavily on close university-industry-government interaction. While we do not suggest emulating the government-dominated industries of many of these nations, our nation will be wise to recognize the benefits of the joint and cooperative relationships.

A recent specific case in point is the development of a new aluminum-aramid composite material for aircraft structural applications. This program was headed by researchers at Deflt University in the Netherlands, in close affiliation with Alcoa Aluminum and Fokker Aircraft.

BENEFITS OF NASA-UNIVERSITY RESEARCH -

Cost Benefits to the University:

Technical education requires very expensive laboratory and computational facilitities. Most universities simply cannot afford to develop and support these important facilities with only state and private resources. Shared use by federally-sponsored projects provides the financially underpinning required for sustaining these laboratories, described earlier.

Faculty-NASA Interactions:

NASA has an excellent history of close cooperation and interaction with universities in research, dating from its predecessor agency, the National Advisory Committee for Aeronautics. NASA's university grants and contracts program, the summer faculty and visiting researcher programs, and the very excellent laboratories and research teams have provided this nation with unquestioned leadership in aeronautics and space.

Graduate Assistantships:

Graduate assistantships are one of the key elements to meeting our future needs for technical leadership. Federally sponsored research projects have the dual benefit of providing incentive for bright young people to pursue graduate education, and providing them with the experience of participating in valuable, credible, state-of-the-future research.

The investment in education made by previous government programs which support graduate education is paying rich dividends. Graduates from WSU's science and engineering programs currently serve with every major NASA laboratory, with every major aerospace manufacturer, and with each of the military services. Many of our current engineering and science faculty members received graduate school training through NASA or NSF fellowships of the 1960's. As a personal note, I received support for my doctoral studies through the NSF Science Faculty Fellowship program of that time period, and I am extremely grateful for that support.

PROBLEMS AND SHORTCOMINGS OF PRESENT NASA-UNIVERSITY RESEARCH -

Short Duration Commitment:

A principal problem for university researchers is the relatively short range of commitment to important and fundamental research problems.

Case-in-Point: Stall-Spin Prevention

NASA has provided leadership over the years in understanding the complexities of aircraft stall and spins. Recently, funding for stall-spin research has been suspended to support other activities. The reason cited for this change is that since stall-spin research was supported for many years the problem should be solved by now. In fact, inadvertent stalls and spins continue to be one of the most frequent causes of accidents, particularly in small aircraft. We have a modest program of unique research in this area at Wichita State University, supported by an FAA contract. Our research utilizes the best in modern computation to attack the very complex analysis of the aerodynamics of an airplane manuevering into and through the stalling and spinning motions. As our simulator becomes fully operational, industry designers will be able to study the stall and spin behavior of their new designs prior to first flight. This will result in design improvements before flight, reducing flight test time, cost and hazards, and will result in safer aircraft entering the marketplace. Continued funding is crucial, however.

Emphasis on Computers Rather Than Experiments:

The dramatic increase in capability and reduction in cost of computers has resulted in our investing in them an ever-increasing amount of resources. Advanced computers are an essential element for maintaining world leadership in aviation. Computer studies are usually less expensive than experiments. None-the-less, careful experimental research is required to verify the computer studies. Furthermore, just as the marriage of the computer with the milling machine is providing dramatic productivity increases for our shops, so also is the computer capable of increasing the productivity of our experimental facilities. Modern electronics provides instrumentation of unprecedented quality and speed. We need not only new wind tunnels and other laboratories in some cases, but we need to upgrade older facilities with new instrumentation and data processing computers.

Case-in-Point: Helicopter Rotor Development

A unique high performance helicopter rotor tip shape recently appeared on the new British Westland helicopter. The British reportedly developed this rotor using experiments because they did not have the money to commit to supercomputers for advanced fluid dynamic computation. Evidently, researchers in the U.S. had invested such great resources in computing capability that our experimental capabilities have been neglected.

Need for Balance Between Development and Exploratory Research:

Everyone wants to support exploratory research, while almost no one is enthusiastic about support of development. It is often argued, and not without merit, that development is the role of

the manufacturer rather than the government research lab. On the other hand, it seems that the current style of research funding in the aeronautics side of NASA is severely limited in the area of development.

Case-in-Point: In our own experience at WSU the EIDI research has clearly demonstrated the capability of removing ice from airplane wings. Why then are there not yet any operational aircraft which utilize this new technology? The answer lies in the secondary issues and obstacles which require evaluation and study to assure the airworthiness of the entire system. For example, will the equipment fatigue the aircraft skin, and cause structural damage over an extended period of service? What will be the effects of the strong electro-magnetic impulse on radio, navigational and other electronic equipment? It is these issues that must be resolved, yet funding has been very difficult to obtain to address these issues. It is my opinion that closer cooperation between government and industry, and more applied or developmental research will reduce the lag time between innovation and application.

CHARACTERISTICS OF A SUCCESSFUL RESEARCH CENTER FOR THE 1990'S AND BEYOND -

To meet the dual challenges of rapidly emerging technology and foreign competition in the aerospace industries, several things are desirable for a research organization.

1. A unique mission, so that the research center does not merely duplicate expertise available elsewhere.

2. Intimate links with a university motivated to support the research mission.

3. Location in an industrialized urban setting, so that interaction with supporting industry can take place on a daily basis.

4. A "critical mass" of researchers and scholars from a variety of disciplines, but with common goals.

5. An adequate number of students and academic programs to support the mission of the center.

6. An identified research facility, so that university, industry and government researchers can perform their tasks separate from, but in close proximity to the educational functions of the university.

7. Experimental and computational facilities which are adequate to support the research theme of the center.

8. Support from appropriate local, state, regional and national agencies.

THE NATIONAL SCIENCE FOUNDATION UNIVERSITY CENTERS PROGRAM -

The recently established Engineering Research Centers and planned Science and Technology Centers of the National Science Foundation have goals essentially as described above. While these programs have had mixed success to date, we believe that the Center concept is valid, and should be continued. The Institute for Aviation Research at Wichita State University recently submitted a proposal for a planning grant for the NSF Science and Technology Center program. We have learned that the entire STC/ERC program for new centers is in jeopardy for the present year, because of limited resources and the large number of applicants. It is interesting that our organization poses a dilemma for NSF reviewers, since the theme of our research organization is not a traditional discipline, but rather a set of disciplines linked by their common use in a particular industry. We believe that our approach is sound, even though non-traditional. The industrial advisory committee of the Institute is comprised of members of the highly competitive aerospace manufacturing community, who are well-qualified to guide and challenge us to conduct research of relevance to the aerospace industry.

SPECIFIC RECOMMENDATIONS TO THIS SENATE COMMITTEE -

1. Continued support for NASA's manned and unmanned space programs.

2. Increased support for NASA research related to aeronautics.

3. Support for more joint university-industry-government research.

4. Increased support for graduate fellowships in the aerospace specialties.

5. Additional support for interdisciplinary research centers at universities. Sponsorship might be from more than one government agency, when appropriate.

6. Upgrading of experimental facilities of both government and the universities, with particular emphasis on modernization of instrumentation.

CLOSING REMARKS -

We look forward to the challenges of the 1990's and the 21st century. The leaders for that era are currently enrolled in our universities. We believe that with proper leadership from the federal sector, and cooperation from the industrial and educational sectors, this nation can and should retain its preeminince in aviation and space.

Thank you for the opportunity to appear before this committee.

Senator KASSEBAUM. Thank you, Dr. Wentz. Dr. Roskam.

STATEMENT OF DR. JAN ROSKAM, PROFESSOR OF AEROSPACE ENGINEERING, DEPARTMENT OF AEROSPACE ENGINEERING, UNIVERSITY OF KANSAS

Dr. ROSKAM. Thank you, Senator Kassebaum, for inviting me to provide you with some of my thoughts. Good morning Ladies and Gentlemen. What I will do is, instead of echoing almost precisely what my colleague, Dr. Wentz, so well stated, let me emphasize some areas that he did not get into which I think are nevertheless very important. But I must say there wasn't a single thing in his testimony that I wouldn't agree with 100 percent. A slight compliment to our friends at NASA in summary of some of the points in my written testimony.

Within the budget constraints, NASA is doing a good job in working with universities to ensure a better education of engineers and scientists, but we note that duly within the budget constraints.

The point that I would like to make at first is in disagreement with what Mr. Mohling has said, and all I can say is that I am eagerly awaiting the higher quality of students into our Nation's universities. Now, I don't get to see them until they are in their junior year in aerospace engineering, so there's going to be a five to seven year lag before I will see the results of these excellent new students.

Let me say that my view is that the quality of engineering and science students coming into our universities from former eductional institutions, mostly the high schools of course, is poor and getting poorer all the time. And I'm saying this on the basis of 14 years of experience in industry and 21 years experience in the university system. I have seen a gradual but steady erosion of the quality of students coming in.

Let me give you some specific examples. Most local state universities in the United States are now teaching such lofty subjects as Remedial Algebra, Remedial Trig, and believe it or not, Remedial English. Now, we're not doing this because we think it is fun to teach high school subjects, topics, in the university system. We are doing it because the high schools, and my strong view is before them, the elementary schools, aren't doing their jobs. An alarmingly large percentage of my students and those that I get in contact with in my lectures across the United States lack fundamental knowledge in the following areas: One, mathematics. I find that even after two years of college calculus and differential equations, many of my students, an alarming number of my students do not

have the fundamental skills necessary to set up a problem and solve it. Math modeling is apparently something that is not being emphasized at all, not even at the universities.

History, U.S. and World History, virtually all my engineering students, and by the way, we're supposed to be getting the best in engineering, are ignorant in these areas. Even in the area of U.S. History, Geography, U.S. and World Geography. I tell you, you put a globe in any of my classrooms and you ask the kids where's New Zealand, where's Indonesia, they don't have the vaguest idea. I think it's terrible.

English, many of my engineering students do not have the ability, folks, believe it or not, they do not have the ability to express themselves in rational English. And their spelling is atrocious, and that's not the classical fun-poking statement. You hear people say engineers can't spell. There aren't very many students who can spell their own language, period.

Foreign languages. I have in my junior and senior class together one student who speaks a little German. How in the world are we going to get along in this world if we do not learn foreign languages. Now, to me, it's the top of arrogance for us to expect that other people to whom we want to sell our products automatically will adopt our language. When a Japanese salesman comes to the United States, they don't expect us to know Japanese, they speak English. When our salesmen go to France, they expect the French, who are very proud and protective of their own language, they expect the French all of a sudden to speak English. No wonder we're getting a bad name, no wonder our products aren't selling, we're not really even trying. But the sad thing is we are not properly preparing the kids.

Secretary of Education Bennett, of course, sometime ago proposed this advanced "going back to basics" high school curriculum. I think he was absolutely right, and my only complaint about Secretary Bennett's statements was that I strongly believed that he was understating the urgency of the country's situation.

Let me say that many students that get into our universities are totally unprepared as they come out of the high school system for the rigors of scientific and technological studies, and it matters not how much money you give for the Space Program if we don't get this long-term educational deficiency resolved.

Let me also make a few points with regard to the cost that we incur as a nation because of this rising tied of mediocrity and ignorance which I still see going on. You've all heard about the B1 crash, the airplane that flew against a pelican, all right, and it crashed. It didn't really crash because it hit a pelican, it crashed because of a major design stupidity which was based on ignorance. Flight crucial hydraulics were burried in the leading edge of that airplane. Now, that's in the literature. If people just have the habit of reading the literature, they would have known about that. My friends at Boeing are probably going to be a bit mad at me for making the following statement. The Japan Airlines 747 crash that killed something like 500 plus people was caused by, and you can point at a whole bunch of technical effects that were the cause, but the direct cause, in my opinion, was that Boeing engineers don't read French. Because had they read French, they would have been

aware of an accident investigation report that was written in French that warned exactly against that kind of an occurrence. And by the way, I must say my friends in Europe designed the Airbus because they did read that report so that kind of an eventuality could not happen.

There are cost overruns in the aerospace industry, particularly in the software arena, in the flight controls arena, that are the direct result of ignorance relative to things that happened in the past, things that went wrong in the past. People don't read, and I believe they don't read because they're not being pushed to read at an early enough age.

Thank you, Senator.

[The statement follows:]

STATEMENT OF

Dr. Jan Roskam, Ackers Distinguished Professor of Aerospace Engineering, Department of Aerospace Engineering, The University of Kansas.

In my testimony I will address the specific issues raised in the 2-24-88 letter from Senators Holling and Riegle to me.

1. Nature of NASA/University Relations

Within its budget constraints NASA has done a good job of maintaining relationships with universities. Typical of existing NASA/University programs are:

a) Graduate Student Support Program

In this program, NASA supports a graduate student to work at a NASA center for approximately one year. During this time the student works together with experienced NASA researchers and develops expertise in some problem area. After that time the student returns to the university to finish any course work and to write his thesis. During the entire period, NASA provides a reasonable level of financial support for the student.

b) Research Grants and Contracts

In this program, professors acting as principal investigators propose specific research programs to their counterparts (grant or contract monitors) at a NASA research center. When the grant or contract is approved the professor normally will assemble one or more students (research assistants) to help him with the research. This provides the students with valuable experience and some financial support. It provides the faculty with release time or with summer salary.

c) NASA/USRA Space and Aeronautics Design Program

In this program, selected universities receive funds to allow students to spend summertime at NASA research centers to gain experience with advanced methods of analysis in aerospace technology. During the academic year the students work on an advanced design project under the guidance of a faculty member. One teaching assistant is fully funded by this program. The main purpose of this program is to add competent young blood to the advanced design capability of the USA.

d) University Space Engineering Research Center Program

As part of the new CSTI (Civil Space Technology Initiative) program NASA hopes to kick off a University Space Engineering Research Centers Program. Under this program NASA intends to fund eight universities at an annual level of 0.5 to 1.0 million dollars. The main purpose behind this new NASA/University initiative is to improve the quality of and to increase the number of US born space engineers and scientists.

Note: The University of Kansas is one of 115 universities which have submitted bids to NASA for this program.

2. Value and Benefits of NASA Programs as an Educational Tool

The value of these NASA/University programs in terms of enhancing the quality of engineers and scientists which graduate from our universities cannot be overestimated. I believe it is essential for students as well as faculty to get exposure to 'cutting-edge' problems in aerospace science and technology. These programs facilitate this process.

NASA Center researchers and NASA Headquarters managers have done an excellent job (within the available funds) of working with the universities on these programs.

The only problem I see with all NASA/University programs is that available funds are not sufficient to cover the need.

3. Value and Benefits of NASA Programs to Technology Initiatives

There are two aspects to this:

3.1 Initiatives by Industry

3.2 Initiatives by Universities

3.1 Initiatives by Industry

There is a long and distinguished record of NACA and NASA programs which led directly to industry initiatives which in turn resulted in major commercial and military applications.

Some recent examples are: supercritical airfoils
winglets
propellers and propfans
high density electronic circuits as driven by space program needs
computational aerodynamics technology
parameter identification technology
laser gyro and much of laser technology

3.2 Initiatives by Universities

The mere existence of the NASA grant program has been used by many universities to initiate research programs which ultimately led to significant commercial applications (in addition to the educational benefits).

Some recent examples: modern control theory and applications
separate control surface technology
flow visualization technology

4. K.U. Interaction with NASA

The University of Kansas has maintained very good relations with several NASA centers in the following areas of aerospace technology:

4.1 Aeronautics

4.2 Remote Sensing

4.3 Space Science

In the recent past as well as today several of the research projects in Aeronautics are carried out in cooperation with industry. This not only helps spread technological information directly to U.S. industry but it gives students and faculty an appreciation for 'real world' constraints and problems.

At The University of Kansas we are currently working with NASA on the following specific programs:

4.1 Aeronautics:

1. Computational Aerodynamics Research
   (5 projects, totalling $68,000)
2. Airplane Ride Quality Improvement
   (1 project, current funding in doubt)
3. Laminar Flow Research
   (1 project, funding ends spring 1988)
4. USRA Aircraft Design Program
   (Design of two 300 passenger transports with transpacific range: one for Mach 2.5, the other for Mach 4.0)

5. Graduate Student Support Program
(Two projects: one in STOL handling qualities and the other in compressor distortions)

Total funding: $ 320,000

Principal investigators: Lan, Downing, Farokhi, Smith and Roskam

4.2 Remote Sensing: 1. Radar Back Scattering of Sea Ice and Water Surfaces

2. Development of a Modern Radar for Antarctic Research

Total funding: $ 456,000

Principal investigators: Moore, Surana, Rummer, Zeller

4.3 Space Science: 1. Voyager Mission Support

2. Galileo Science Support

3. Ulysses Science Support

4. Spacecraft Electrical Charging in Low Earth Orbit

5. Space Plasma Physics

6. Investigation of Global Geotail (energetic particles)

Total funding: $ 190,000

Principal Investigator: Armstrong

5. Overall Quality of the Science, Engineering and Technology Infrastructure

There are three aspects to this:

5.1 Facilities and Equipment

5.2 Students

5.3 Ability of Universities to Produce the Next Generation of Engineers, Scientists and Technologists

5.1 Facilities and Equipment

Many of our universities have very INADEQUATE facilities and equipment to perform their educational function in a 'high tech' world. Such is certainly the case at The University of Kansas.

To save space in the congressional record, let me give you JUST ONE EXAMPLE OF THE URGENCY of this situation!

In my area of expertise, aerospace vehicle design, it is essential to use advanced 3-D CAD (Computer Aided Design) workstations, if the quality of design education is to be on par with industrial applications of CAD. At The University of Kansas, my design laboratory consists of:

Facility: two rooms, one 310 sq.ft, the other 1110 sq.ft.

Equipment: 3 Apollo workstations, 4 personal computers, two printers, one small plotter and one graphics station.

With the exception of the graphics station, ALL other equipment was paid for with money which I personally managed to attract to the university! No taxpayers money is available for this type of equipment.

This equipment is currently being shared by 65 students.

My collegue, Professor Torenbeek, at Delft University of Technology in The Netherlands, has the same number of students. His design laboratory consists of:

Facility: the sixth floor of a large, 13-story building which is the home of the Department of Aerospace Engineering. In addition he has a fairly large and modern aircraft collection (I mean aircraft, not models!) housed in a good size hangar adjacent to his design laboratory.

Equipment: 25 Apollo workstations and 25 Sun workstations, 30 personal computers, 10 printers, 4 large plotters and 5 graphics stations. All equipment was paid for by the Dutch taxpayers.

All else being the same, it is clear where students are getting the better education: our foreign competitors are way ahead!

This is only one example. I could give you many more of such examples. It is a sad fact that as a nation, we spend far too little on education. If we continue along this road, there is not a chance, that the USA will play a significant role in technology in another 15-20 years.

5.2 Students

Since I came to The University of Kansas from The Boeing Company (21 years ago) I have witnessed a steady erosion in the quality, general ability and general knowledge of american born students.

Most state universities in the USA are now teaching such lofty subjects as:

Remedial Algebra, Remedial Trigonometry and (SIC!) Remedial English.

An alarmingly large percentage of my students lack fundamental knowledge in the following areas:

Mathematics: Even after two years of college calculus and differential equations!)

History: U.S. and World history: they are simply ignorant in these areas!

Geography: U.S. and World: they are simply ignorant in these areas!

English: many do not have the ability to express themselves in rational English and their spelling and grammar is terrible!

Foreign Languages: hardly any have any knowledge of a foreign language!

Secretary of Education Bennett is absolutely correct in his crusade for better education at the High School and at the Elementary School levels. My only complaint about his public statements is that he is UNDERSTATING the urgency of the situation!

When you take a look at which university students around the USA are doing the most advanced research work in science and in technology, you find that most is being done by foreign students and a lot is being done by U.S.-born asiatic students. As a former foreigner myself, I have absolutely nothing against foreigners. But I do wonder if this is a healthy situation for America.

When I quiz my best U.S. born students about their High School education in particular, I always find that they were not challenged, did not have to study very hard (they are very proud of that!) and that they did have a lot of idle time.

Many American students arrive at our universities totally unprepared for the rigors of scientific and technological studies.

Even those students from our best high schools are typically 35% behind their foreign counterparts simply because of the lesser amount of time spent in school. As a society we seem to be willing to spend money for fighting crime, for fighting drug abuse and for building jails. We do not seem to be willing to spend enough money to avoid these problems, to educate them and to keep them in school. Presidential Candidate Jesse Jackson compares these costs and finds that it is 4 times as expensive to do the former than to do the latter! Something just does not make sense here!

Senators: What we have here in education is a national crisis and you had better believe it!

5.3 Ability of Universities to Produce the Next Generation of Engineers, Scientists and Technologists

I like to start by writing an equation used in the design of aerospace control systems:

OUTPUT = (TRANSFER FUNCTION)*INPUT

Engineers, scientists and technologists are the OUTPUT in this equation.

The universities with their faculties, facilities and equipment are the TRANSFER FUNCTION in this equation.

The high school graduates are the INPUT in this equation.

If the INPUT is poor, it is not reasonable to expect that the universities can arrange their transfer function so that the output is of world class. The INPUT is very poor as already observed in Item 5.2! A major priority for the USA should be to improve the QUALITY AND QUANTITY of elementary school and high school curricula.

If the TRANSFER FUNCTION is poor, even a good INPUT won't do much good. The facilities and equipment situation at our universities is very bad indeed. It might surprise you to learn that (at least in Kansas) there does not exist a line item funding plan for:

1. Modern equipment acquisition consistent with technology requirements
2. Accumulation of replacement budgets for that equipment which becomes rapidly obsolete because of advancements in technology. Computers, operating software and workstations all are in this category.
3. Facilities to house the equipment.
4. Hiring of technicians to support the equipment.

It is my observation, that at least in the State of Kansas the State Legislature does not seem willing to make the investments needed to create a truly excellent education in science and technology. From discussions with collegues, I believe that much the same situation exists in most other states.

6. Summary of Testimony

1. Within the budget constraints NASA is doing a good job in working with universities to assure a better education of engineers and scientists.
2. The quality of engineering and science students coming into our universities from the U.S. educational system is poor and getting worse all the time!
3. Much of the advanced research work done at our universities is done with foreign students, mostly because their background in mathematics and sciences is much better than that of U.S. educated students.
4. Of course, there are still some very good US born engineering and science students who would like to go to graduate school. It is very difficult with the few research dollars available, to convince U.S born students to stay in graduate school.

5. The facility and equipment situation in many of our universities is very bad indeed. This has a NEGATIVE effect on the quality of the graduating students.

6. I do not believe that U.S. universities in general can be expected to deliver world class engineers and scientists as required to secure our nation's technological and industrial future.

7. As a nation we need to spend much more money on education at ALL levels. When and if we do, I would hope that TIGHT PERFORMANCE CONTROLS AND STANDARDS will be adopted to assure efficient use of the taxpayer's dollars.

8. As a nation we must spend more money on aeronautics and space research programs. A lot of our industrial future hinges on this.

From my statements sofar, you should get the impression that I strongly believe in the value of NASA's work in aerospace and in aerospace education. And indeed I Do!

What I DO NOT see is: much evidence of strong political leadership to support our civil aerospace and our education programs. The goals as stated in Dr. Sally Ride's report are all very worthwhile. But Senators: how in the world do you expect to ever achieve these goals without supporting the legislation needed to raise the required funds?

What I DO NOT see is: a congressional, nor a presidential commitment to a sound civil space program.

I am convinced, that the U.S.A. CANNOT AFFORD a civil space program if it does not bridge the gap caused by the fiscally and morally irresponsible policies of the past seven years. Please read the attached editorial which recently appeared in the British magazine: Flight International.

This does raise THE IMPORTANT question:

HOW DOES ONE CONVINCE THE AMERICAN TAXPAYER THAT THEY NEED TO SPEND MORE MONEY FOR EDUCATION AND FOR AEROSPACE? Particularly when:

a) We now have large numbers of homeless people!

b) We now have large numbers of people living in poverty!

c) We now have large numbers of people without any reasonable medical care!

d) We now have large numbers of functional illiterates!

e) We now have one of the highest infant mortality rates among free democracies!

f) We have large numbers of high school dropouts with nobody to really care for them. Many acquire drug habits and many become juvenile delinquents. Then we complain about the lack of jail facilities!

g) We have more than 50% of the eligible voters who feel so disenfranchised (mostly because of a) through f), that they don't even bother to vote!

The real question is:

Can we, as relatively wealthy engineers, professors, managers and senators, ask the taxpayers (with a straight face) to spend more money for education and for aerospace IF at the same time as a group we are not willing to recognize the obvious needs of large segments of our society nor are we willing to volunteer to pay the extra taxes required to address those needs?

Senators, I think you have several tough issues in front of you!

Senator KASSEBAUM. Thank you very much, Dr. Roskam. Dr. Spooner, you may begin.

STATEMENT OF DR. BRIAN SPOONER, PROFESSOR OF BIOLOGY, DIVISION OF BIOLOGY, ACKERT HALL, KANSAS STATE UNIVERSITY

Dr. SPOONER. Senator Kassebaum, Committee staff, and distinguished panelists, members of the media and concerned citizens, I'm pleased to present testimony on the Civilian Space Program from the perspective of the Kansas State University, Division of Biology. I'll discuss the values and benefits of NASA Programs, how these programs enhance our activities at the university level, and their importance in training our next generation of scientists. In contrast to most of today's speakers, biology and life sciences will be the continuing focus of my comments.

I'll offer my summary testimony in the following order. First, I'll briefly discuss who and what we are in the Division of Biology at Kansas State University. Second, I'll indicate the general extent and status of our NASA affiliations. Third, I'll introduce you to BioServe Space Technologies, a NASA Center for the Commercial Development of Space. Fourth, I'll outline what I see to be the impact of our NASA affiliation contributions. And finally, I'll detail our recommendations for future decisions.

The Division of Biology was formed 20 years ago by the merger of several departments at Kansas State University and is the largest administrative unit within the College of Arts and Sciences. The division is responsible for all fundamental Biology at Kansas State and possesses demonstrative strengths in molecular, cellular, developmental, environmental, and systematic biology. One of our unique characteristics, therefore, is the broad range of life sciences research expertise we command; from ecology, to physiology, to cancer biology, to recombinant DNA technology.

The Division of Biology is strongly research oriented. The outstanding quality of our faculty is documented by our success in competition for extramural research support, with competitive research funding of about 4 million dollars brought into the State of Kansas during the past year alone. The strengths of the faculty have resulted in a number of unique programs in the division, including the Division's Center for Basic Cancer Research, its National Cancer Institute training grant, its participation in the Wesley Scholar Cancer Training Program, and its management of the 8,600 acre Konza Prairie research natural area.

With regard to NASA affiliations, the division has recently formally interacted with NASA on a Konza Prairie-Based Research Program. This project involved selection of the Konza by NASA as the site for the First International Satellite Land-Surface Climatology Project. This project is international in scope and clearly represents the kind of remote sensing project envisioned in the Mission to Planet Earth initiative currently under consideration at NASA.

The division also interacts with NASA on a broader basis in life sciences research. Capitalizing on our strengths and diversity, we have recently expanded into new frontiers, beyond the traditional research laboratory, beyond the research prairie, and into space,

culminating in the formation of BioServe Space Technologies, a NASA Center for the Commercial Development of Space.

Developed by scientists in the Division of Biology, in cooperation with our colleagues in the Department of Aerospace Engineering Sciences at the University of Colorado, BioServe became the newest center in the NASA complex of CDS centers when it was officially designated and funded in October 1987. Some 20 individual and independent faculty scientists in the KSU Division of Biology now have ongoing research projects investigating biological processes and products in space.

Do benefits result from such affiliations? We in the Division of Biology at Kansas State University recognize distinct benefits that will result from our affiliations with NASA. These contributions will impact at three levels; increasing knowledge through basic research, training a new generation of space-oriented scientists, and finally, assisting in the development of a space-literate population. We see impact from our research contributions, our training contributions, and our public contributions.

With regard to research contributions, faculty research will increase fundamental knowledge of the effects of gravity on basic cellular processess in plants and animals. Faculty research will also enhance opportunities to determine the effects of weightlessness on biological systems. Faculty research will contribute to the development of Controlled Ecological Life Support Systems to maintain plant and animal health in the space environment. And faculty research will foster the development and production of new bioproducts to benefit the world's population.

With regard to training contributions, we will expand our human scientific resources by training a new core of space scientists. These undergraduates, graduate students, and postdoctoral fellows, will be trained in the biological sciences but will also be comfortable with the challenges and opportunities provided by the space environment. We will further expand our human scientific resources by integrating the scientific life sciences endeavors of researchers in government, university, and industry. An example of such integration is our forthcoming workshop in Cell and Developmental Biology, designed for aerospace engineering graduate students and industrial space scientists.

Finally will be our general public contribution, which is, as I see this morning, an extension of the Teacher in Space Program. Particularly beneficial will be our contribution to what I've called the creation of a space-literate population. This benefit will result from increased visibility of space-related activities on a 20,000 plus student campus and by increased visibility throughout the State and Nation. The space-literate student population will include those individuals not formally trained in space biology who will be the farmers, bankers, homemakers, and business people of the next generation.

We believe that our impact at the State and National level has already occurred through vigorous and active public awareness activities that provide important information about NASA and NASA affiliated programs.

As for our recommendations, we support a strong NASA and Congressional commitment to the development of the Space Sta-

tion. However, such development must be coupled with a dramatic increase in NASA's focus on the life sciences component of the United States Space Program. It's also time for increased visibility of NASA's funding opportunities for life sciences research through nationwide solicitation of proposals and a solid, peer-review mechanism for award decisions. Finally, it's also time for higher flight status priorities for life sciences research.

In conclusion, on behalf of the Kansas State University Division of Biology and its BioServe component, I thank you for the opportunity to testify. Clearly, our concerted efforts in life sciences research are required to ensure success in all of the NASA Space Program. Thank you very much.

[The statement follows:]

STATEMENT OF BRIAN S. SPOONER, PH.D., PROFESSOR OF BIOLOGY, DIVISION OF BIOLOGY, KANSAS STATE UNIVERSITY, MANHATTAN, KS

INTRODUCTION

Senator Kassebaum, honorable committee members, distinguished panelists, members of the media, concerned citizens, my name is Brian Spooner. I am a professor in the Division of Biology and a member of the BioServe Life Sciences Steering Committee at Kansas State University, Manhattan, Kansas. I appreciate this opportunity to address you and to present this testimony concerning critical elements of the civilian space program. In particular, I shall discuss what I perceive to be the values and benefits of NASA programs to technology initiatives, how these programs enhance our educational and research activities at the University level, and the importance of these programs in the development and training of our next generation of scientists. Biology and life sciences will be the continuing focus of my comments today.

NASA's Life Sciences Division summarizes its three-fold mission in this way—to enable, to protect, and to explore. By "enabling human beings and other species to safely venture into space; [by] protecting the fragile biosphere of Earth; and [by] exploring the universe for evidence of life forms that may exist on other planets," NASA leads our nation's efforts to understand our planet and the universe beyond. In doing so, it requires the close cooperation of the ablest scholars our nation can provide from within NASA, our universities, and our industrial sector.

I am pleased by the Committee's invitation to be here today, and I shall offer my testimony in the following order:

First, I shall briefly discuss—who and what we are in the Division of Biology at Kansas State University.

Second, I shall indicate—the general extent and status of our NASA affiliations.

Third, I shall introduce you to—BioServe Space Technologies, A NASA Center for the Commercial Development of Space.

Fourth, I shall outline for you—the impact of our NASA affiliation contributions.

Finally, I shall detail—our recommendations for future decisions.

DIVISION OF BIOLOGY, KANSAS STATE UNIVERSITY

The Division of Biology is uniquely qualified to share with NASA a leadership role in life sciences space research. Formed 20 years ago by the merger of several departments at Kansas State University, the Division of Biology is the largest administrative unit within the College of Arts and Sciences. With 43 full-time faculty positions, it is responsible for all fundamental biology at Kansas State. A National Science Foundation Center of excellence Award initiated an expansion and strengthening of the Division in the areas of molecular cellular, developmental, environmental, and systematic biology. Our unique qualifications, therefore, lie in the broad range of life science research, from ecology—to physiology—to cancer biology—to recombinant DNA technology.

The Division of Biology is strongly research-oriented with intramural support for basic and applied research provided by the Kansas Agricultural Experiment Station and the KSU Bureau of General Research. The outstanding quality of the Division's faculty is documented by our success in competition for extramural research support. During the last year alone, competitive research dollars of about $4 million were won by our faculty and brought into the state of Kansas. The diverse and well-

documented scientific strengths of the faculty have resulted in many unique research and educational programs in the Division of Biology, some of which I will touch upon briefly.

Center for Basic Cancer Research: Molecular, cellular, and developmental biologists at Kansas State University make strong contributions to fundamental cancer research and cancer research education. The Kansas Regents Universities have designated the Division of Biology as the Center for Basic Cancer Research, and a new Anti-Cancer Drug Laboratory functions within the Division to study the cellular and molecular events associated with tumor promoters.

Virology and Tumor Biology Training Grant: In 1981 a new interdisciplinary graduate training grant in Virology and Tumor Biology was awarded by the National Cancer Institute. The award enhances student participation in a multidisciplinary approach to tumor biology that includes biochemistry, immunology, molecular biology, cell biology and virology. In recognition of the quality of this program, an additional four years of funding was awarded in 1985.

Wesley Foundation Cancer Research Training Program: In an agreement just signed in January 1988, the Wesley Foundation of Wichita, Kansas has joined with the University of Kansas and the Division of Biology at K-State to establish a new, interdisciplinary Cancer Research Training Program. This award promotes the recruitment of new scientists/trainees to the field of cancer research. A select core of qalified senior investigators, including 14 from the KSU Division of Biology, constitutes the training faculty for this program.

Konza Prairie Research Natural Area: A particularly unique facility is the 8,616-acre Konza Prairie—the world's largest native tallgrass prairie set aside for land management and ecological studies. In 1980, the National Science Foundation (NSF) selected the Konza Prairie Research Natural Area for inclusion in the network of research study sites of the United Nations Biosphere for Man. NSF also selected the faculty in the Division of Biology to participate in the Long-Term Ecological Research Program. In recognition of the diversity and quality of this program, the NSF award for research on the Konza Prairie Research Natural Area was competitively selected for renewal in 1985.

Kansas Agricultural Experiment Station: An unusual and productive interaction exists between the faculty scientists in the College of Agriculture and in the College of Arts and Sciences. Twenty-four of the faculty in the Division of Biology have appointments with the Kansas Agricultural Experiment Station. Many of the research programs and goals, therefore, represent joint efforts among scientists across college boundaries.

In summation, the Division of Biology is a unique component of Kansas State University. The Division is the largest, single administrative unit within the College of Arts and Sciences and has a remarkably diverse array of research programs, ranging from DNA technology and cell biology to ecological and agricultural studies. Furthermore, these programs involve students from undergraduate through postdoctoral levels and involve a major community, state and national educational focus.

NASA AFFILIATIONS

NASA's affiliation with the Division of Biology at K-State is not new. For example, an early interaction involved the inflight utilization of a water purification system developed by KSU biology and chemistry scientists.

More recently, the Division of Biology formally interacted with NASA on a Konza Prairie-based research program. This project involved selection of the Konza Prairie Research Natural Area by NASA as the site for the First International Satellite Land Surface Climatology Project. This project is international in scope and joins scientists from the Division of Biology with colleagues from NASA, France, Canada, and England. Clearly this collaboration represents the kind of remote sensing project envisioned in the "Mission to Planet Earth" initiative currently under consideration by NASA.

Finally, the Division of Biology interacts with NASA as a major partner in promoting the three-fold mission of the Life Sciences Division mentioned eariler. Capitalizing on its strengths and diversity, the Division of Biology has recently expanded into new frontiers—beyond the traditional research laboratory, beyond the research prairie, and into space—culminating in the formation of BioServe Space Technologies, a NASA Center for the Commercial Development of Space.

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BIOSERVE SPACE TECHNOLOGIES, A NASA CENTER FOR THE COMMERCIAL DEVELOPMENT OF SPACE

Scientists in the Division of Biology, in cooperation with their colleagues in the Department of Aerospace Engineering Sciences at the University of Colorado, developed the concept for BioServe Space Techologies, a NASA Center for the Commercial Development of Space. BioServe Space Technologies became the newest center in the NASA complex of CDS Centers when it was officially designated and funded in October, 1987. The Center focuses on research and training activities across the full range of biological and biomedical sciences. Some 20 individual faculty scientists in the KSU Division of Biology now have ongoing research projects designed to investigate biological processes and products in space.

BioServe Space Technologies is exceptional in that it provides an interactive partnership between NASA, industry and the academic community. This partnership will foster the pursuit of commercialization opportunities that particularly capitalize upon life-sciences strengths, including biotechnology, biomedicine, and agrisciences. In order to adequately prepare for these challenges, ground-based research in support of space flight experimentation is crucial. These strengths will be combined with another precious resource—access to space—to promote the goals of "enabling human beings and other species to safely venture into space; protecting the fragile biosphere of Earth; and exploring the universe for evidence of life forms that may exist on other planets."

Emphasis on our research contributions without consideration of our educational mission would sadly underestimate our view of the role of BioServe Space Technologies in long-term space initiatives. The space training we will provide will give the next generation of biologists, engineers, and others the awareness of opportunities in space sciences that will involve them intellectually, if not physically, in future space missions. In addition, the visibility that BioServe Space Technologies will provide will contribute to the generation of a space-literate population.

THE IMPACT OF OUR NASA AFFILIATION CONTRIBUTIONS

We, in the Division of Biology at Kansas State University, recognize distinct benefits that will result from our affiliation with NASA. These contributions will impact at three levels—increasing knowledge through basic research discoveries, training a new generation of space-oriented scientists, and assisting in the development of a space-literate population. We believe that the actual and potential benefits, i.e., the likely benefits, of our interaction with NASA will include: research contributions; training contributions; and, public contributions.

Research contributions . . . faculty research will:

increase fundamental biological knowledge of our planet and the effects of gravity on basic molecular, cellular and developmental processes in plants and animals;

enhance opportunities to determine the effects of weightlessness upon living organisms and biological materials;

contribute to the development of controlled ecosystem life support systems to maintain plant and animal health in the space environment; and

foster the development and production of new biopoducts of direct benefit to our world's population.

Training contributions . . . we will expand our human scientific resources by:

training a new core of space scientists. These undergraduate students, graduate students, and postdoctoral fellows will be trained in the biological sciences, and will also be comfortable with the challenges and opportunities provided by the space environment; and,

. . . we will further expand our human scientific resources by:

integrating the scientific life sciences endeavors of researchers in Government, University, and Industry. An example of such integration is our forthcoming workshop in Cell and Developmental Biology, designed for aerospace engineering graduate students and industrial space scientists.

. . . and finally, will be our

General public contribution

a particularly important benefit will be our contribution to the creation of a space-literate population. This contribution will result from increased visibility of space-related activities on a 20,000+ student campus and increased visibility throughout the state and nation.

The space-literate student population will include those individuals—not formally trained in space biology—whol will be the farmers, bankers, homemakers, and business people of the next generation. We believe that our impact at the state and national level is occurring now through vigorous and active public awareness activities

aimed at providing important information to the public concerning NASA-related and NASA-affiliated programs.

RECOMMENDATIONS

Senator Kassebaum, as you have so clearly stated, it is "only with continued research and development in science and technology, coupled with a strong educational program at all levels, [that our technological] edge can be maintained."

After a quarter-century of space flight, precious few experiments have been flown which study the effects of space flight on living organisms. With that in mind, we believe it is time for:

a strong NASA and Congressional commitment to the development of the Space Station.

The development of the Space Station must be coupled with:

a dramatic increase in NASA's focus on the life sciences component of the United States' Space Program.

It is also time for:

increased visibility of funding opportunities for life sciences research through nationwide solicitation of proposals and a solid, peer-review mechanism for award decisions.

It is also time for:

higher levels of flight status priority for life sciences research.

And finally, it is time for:

spacecraft, such as LifeSat and biosatellites, dedicated specifically for the biological sciences.

CONCLUDING REMARKS

On behalf of the Kansas State University Division of Biology and its BioServe Space Technologies Component, I thank you for the opportunity to testify on these critical elements of the Civilian Space Program. Clearly, our concerted efforts are needed to ensure that NASA's Life Sciences mission—to enable, to protect, and to explore—will be accomplished.

Senator KASSEBAUM. Thank you, Dr. Spooner. It is a little unorthodox for a traditional hearing, but I would like to ask a couple of questions, and then because of the uniqueness of the panel, I would like to open it to the audience for about four questions. Let me ask all three of you, have you had any problems recruiting or retaining students in the scientific field?

Dr. ROSKAM. At the graduate level, Senator, the tragedy is that even the few good U.S. born students that we manage to attract at our universities are getting such fabulous offers from industry as soon as they graduate, they just can't financially afford to go to graduate school. So, the answer to your question is, no, we are not capable, under the circumstances as they exist today, to guarantee a reasonable supply of U.S. born engineers and scientists for this very worthwhile Space Program. Those graduate students need to be financially supported.

Now, there are some other problems associated with this. In those universities, and mine is one of those, where we are engaged in rather advanced mathematically-oriented research programs, such as Computational Aerodynamics, you find that there you need absolutely people who have the top training and knowledge in mathematics.

I would like to invite all of you to visit my flight research lab at the University of Kansas and look at the faces of the graduate students who are conducting that type of research, most of which is supported by NASA, the U.S. Air Force, and the U.S. Navy, and you are not going to find one single American born face in that group of students. I can't find American students with the right

math background to do that kind of work. So, the answer to your question is we are in serious trouble.

Senator KASSEBAUM. Do you find——

Dr. ROSKAM. May I add one more comment to that?

Senator KASSEBAUM. Sure.

Dr. ROSKAM. There's a report out from the National Research Council. I'm sure that you see these. 50 percent of the assistant professors in engineering in the United States are now foreign born. I have nothing against foreigners, I used to be one myself, as you can probably tell from my accent. But I ask you, is this what we want?

Senator KASSEBAUM. Do you find that true, Dr. Wentz, at Wichita State?

Dr. WENTZ. Yes. I would like to comment that, first, I don't share Dr. Roskam's enthusiasm for the low quality of our entering students. I think we have attracted and continue to attract top students.

But with respect to the graduate assistantship situation, graduate training, this is a serious problem. And the salaries available in industry are so attractive that it is difficult for us to retain our best U.S. born students. I would certainly second that. And we need to be able to increase the stipends and we need more assistantships at the graduate level to help the problem. And it's also, I agree a hundred percent with our—the problem that's associated with that with respect to ensuring education, training the professors of the future, because people from other countries can come here, will come here and survive on the assistantships we afford because of the educational opportunities than are attractive in the educational arena as a career. So, we need to train more U.S. born, more top people for careers in engineering and science education.

Dr. ROSKAM. Senator, I'd like to make one comment. At the risk of people getting the impression that KU manages to attract the lower fellows, I would like to point out that the Aerospace Engineering Department of the University of Kansas ranks number eight in the Nation in aero programs.

Senator KASSEBAUM. Thank you very much. Dr. Spooner, do you, in the life sciences, find the same development?

Dr. SPOONER. Well, in all probability, such a development will occur. It's in its infancy, as I see it. Engineering degreed students have been attracted to industry for years and that competition is existent. In the biological sciences, it's only in recent years, with the successful advent of industrial biology, bioengineering, biotechnology companies, that that equivalent kind of drain on potential graduates, student pool, is coming into focus. So, I don't think we are at that stage yet.

Also, we have good graduate students. We have quality graduates, and I don't want to suggest that qualified undergraduates from Kansas University attend either Kansas State and major in Biology, or Wichita State. But we, the students that we turn out, our students compete successfully throughout the Nation at all levels. The students that we have are good. Everybody wants more and better students. But I do agree with my colleagues that there will, in the biological sciences, be a drain from industrial competition.

Senator KASSEBAUM. Dr. Wentz, you mentioned, and I assume Dr. Roskam and Dr. Spooner agree, that a major problem is the short-term commitment research grants and focus. I've been told that more time is spent sometimes writing proposals than in actual research. I think that is a very sad turn of events, if that is the case. What do we do to change that?

Dr. ROSKAM. Long-term planning.

Senator KASSEBAUM. Well, now, Dr. Hinners over here is shaking his head. Go ahead, Dr. Wentz, maybe you want to answer the question.

Dr. WENTZ. Well, I think that's also related to the problem with retention of graduate students. If we have—typically, research grants and contracts are awarded on, I mean, very often on a single-year basis, renewable. So, we have to compete, we have to prepare for the next year. And how do we commit to the student that wants to come in and be here for three or four years in graduate school with a one-year assistantship. You know, that's a difficult career decision for that person to make. So, we're struggling in competing to try and fill those gaps.

The longer term grants and contracts would be very helpful, a three year pattern, for example, on a contract. We certainly, we want to produce quality and we want to be reviewed and we don't want to waste the money. We want to do a good job with our research money, but the business of having to scratch each year is difficult for us and for our students.

Dr. ROSKAM. I would certainly agree with that. Let me add another aspect to this, Senator, and that has to do with facilities and equipment.

At most of our universities, except in your case with the Aviation Research Institute, which is wonderful, but at most of the universities, the state of facilities and equipment to conduct research and even to conduct undergraduate teaching properly is abominable. What is really alarming is the fact that in most states, and certainly here in the State of Kansas, there doesn't even exist a plan for replacement funding. Computers don't wear out, they become obsolete very rapidly. Measuring equipment doesn't wear out, it becomes obsolete in a hurry. All of that equipment needs technicians to support it and it needs space to utilize it properly. And I do not see any commitment for improving that situation, which is really a very alarming one as you go around the Nation's universities.

Senator KASSEBAUM. Is it true that some of the professors are using equipment that they used as graduate students? I heard somebody say "yes" in the back of the room.

Dr. ROSKAM. I heard that.

Dr. WENTZ. I'm sure it is.

Senator KASSEBAUM. Well, let me ask you, do the short-term commitments contribute to the lack of focus? Is there any relationship between the lack of focus in our space program and the supporting space technologies, or is it the annual nature of the congressional budget process that creates this uncertainty?

Dr. ROSKAM. Let me again get back to this long-term planning idea. The problem that I think is plaguing us as a Nation is the fact that every year we have to go up and defend the budgets.

Let me give you a particular example of some of the problems this results in, and I would like to refer to my colleague, Professor Torenbeek, in the Netherlands, at my old alma mater, Delft University of Technology. He teaches aircraft design just like I do at the University of Kansas. They budget in five-year cycles. And the Dutch taxpayers—you should see the design lab facilities that he has for, by the way, the same number of students that I have. He's got, and I have that in the written testimony, he has 50 engineering work stations, U.S. built engineering work stations, by the way, paid for by the Dutch taxpayers. I now have, and I'm in the area of vehicle configuration and integration design, and you need some fairly expensive pieces of equipment. I have now at K.U. for the same number of students three of those work stations, and I must add to you that I brought in the money to the University of Kansas to buy those work stations personally. Not one dime from the taxpayers of Kansas or the U.S. went into that. That's the difference.

Dr. WENTZ. With respect to the long-term, short-term commitment problem, Senator, in my written testimony there's a specific example of the stall-spin research. You mentioned the focus, lack of focus in space. My interest is primarily in aeronautics, in the aircraft aviation. And in the aviation side of NASA, stall-spin is an area which is a serious safety issue and has been and continues to plague us in terms of accidents. We are interested in pursuing research in this area. We think we are doing some things that are very fundamental and have a long-term impact. We're scratching for money. NASA-Langley has a long-term tradition of research in this area, and their funding has been very, very limited in the last few years. The reason being given is something like, well, you've been working on that for five years, it should be solved by now. We need to be more patient. Serious problems don't go away merely by three or four or five years. These are very fundamental problems. So, I think perhaps some longer range planning with goals not just for the Space Program but also in aeronautics.

Dr. ROSKAM. Along these lines, by the way, there's a very frightening development going on at the NASA and government level, and that's a study the outcome of which will be the closing of flight test facilities at Langley and at Ames and concentrating them all at Edwards, at the Edwards facility. I think that would be a terrible mistake that would certainly put the Stall-Spin Program out of business forever.

Senator KASSEBAUM. I would just share with you from the Congressional side that I, too, think that we really should think strongly about multiyear funding, and perhaps not in all areas but certainly in some. We don't do a very good job analyzing our budgets and making a commitment to them. Perhaps we should change our own committee system so that we can better accommodate multiyear funding and have better oversight of this multiyear funding. We should not micromanage, but simply provide adequate guidelines. I think this is clearly a direction we need to go, too, and I think it is absolutely essential to the conduct of vital, healthy research. I am sure NASA would agree with that.

Dr. HINNERS. Absolutely.

Senator KASSEBAUM. You don't have to testify to that. Let me just open this meeting to questions. Maybe this is catching everybody offguard.

Dr. SPOONER. May I make a comment?

Senator KASSEBAUM. Pardon me, Dr. Spooner. Yes.

Dr. SPOONER. I would like to make a point that is independent of the length of the commitment, the funding commitment, although I agree that the longer the commitment the better. There's another issue, and I've touched on it, and that is the need for a real commitment to biological programs in the NASA component. I mean, our future in space, independently of focus, whether that be for manned or unmanned, whether the focus is to go to Mars or simply a mission to Planet Earth, you need the tools, the equipment, the understanding of basic biological processes in the microgravity environment. And therefore, what has long been the stepsister of NASA Programs, in my view, biological sciences needs elevation to full sisterhood.

Senator KASSEBAUM. I think that's a very good point. Thank you very much. You have a question?

Mr. HOAG. Thank you, Senator, my name is Paul Hoag, spelled H-O-A-G. I have a question about a long-term policy for NASA. This community and this committee is necessarily engaged in the kind of boosterism for high technology, big science programs. I'm wondering if there isn't a role that isn't being talked about in the social sciences and the humanities. You begun to touch on that, Dr. Roskam, when you talked about the need for foreign language training, geography. It seems to me that such a giant, fundamental program is going to have a large impact on the fabric of the society, on our culture and our history. That is naturally the role of value analysis. If we were designing an optimal, long-term, coherent and rational strategy for the 21st Century, authored to be a role for the humanities, for the study of history and culture, it's the impact of the Space Program on our culture and history and a clarification of our values for the program.

Dr. ROSKAM. Well, I won't argue one second against the value of the humanities. In the widest sense of the word, I think an engineer and a scientist isn't truly an engineer and a scientist without having been exposed to a considerable amount of material in the humanities area. So, I agree with you.

Senator KASSEBAUM. All right. Everybody has had their opportunity. Dr. Hinners—whoops, I'm sorry.

UNIDENTIFIED SPEAKER. As an engineering student at Wichita State, I've had Dr. Wentz as an advisor as a freshman. I wonder if there are plans in the university system to broaden the curriculum available to engineering students so that we can get the kind of humanities requirements that were mentioned here today. Because as the system now stands, engineers, engineering students are often limited as to what they're allowed to take because of the incredible number of hours required to graduate. Are we going to allow a broadening of the curriculum for the engineering students?

Dr. ROSKAM. Well, the only way that will come about is if you're going to go into a five-year program. But let me put a little different twist on that if I may. I am a person who was educated quadrilingually. I went through the Dutch high school system, and we

didn't have any choice, we had to learn and become fluent in four languages. That was simply required. And I believe that type of humanities training needs to be done at the high school level. I don't think we ought to let high school kids, immature high school kids, very often parented by rather ignorant parents, select their curriculum. I think there are other people who know better what's good for them.

Now, if you had asked me, as a high school kid in Holland, give me a choice, all right, you don't have to take French but you take basket weaving, you don't have to take English, I wouldn't have taken those things unless the system had made me do that. I think we must do much more of that. More kids are intellectually capable of doing so much more than we demand of them today. And comparing with abroad, comparing with something that was asked a little while ago by Wendell, even if you give the educational system the benefit of the doubt in terms of the efficiency by which knowledge is imparted to them, American kids are 35 percent behind the typical foreigner simply because of the length of time in school.

Now, what's better, keeping these kids in school and making them do work and study and homework or letting them do their own thing, go to New York, go to Los Angeles, go to Chicago, see the juvenile delinquency, and measure the cost associated with that as opposed to the cost of keeping them in school, having more teachers there and letting them learn something useful instead of becoming drug addicts and who knows what.

Senator KASSEBAUM. Dr. Wentz wants to answer.

Dr. WENTZ. I would like to comment that——

Senator KASSEBAUM. That was his student that answered.

Dr. WENTZ. The humanities and social science requirements in fact, in fact, in the College of Engineering at Wichita State, are the same, they are university based requirements. We have a university core, and so those requirements are the same for engineering as they are for all of the students.

Now, it is true the engineering curriculum is full. There are more hours in engineering required than in most other curriculums, so that you usually don't have much spare time, and that's a difficult problem unless you want go to a five-year program.

I do think the area of foreign languages, I really agree with Dr. Roskam in that in an international world, we think about international trade. Certainly foreign languages are something we should begin to think more about, and it is a problem that engineering colleges do not allow foreign language as a part of our accreditation. Our engineering societies haven't come to that point yet. That's unfortunate.

Dr. ROSKAM. They do now.

Dr. WENTZ. In some cases.

Dr. ROSKAM. You can take two courses.

Dr. WENTZ. I can't resist commenting with respect to Dr. Roskam's admonition. I would tell him, as a parent, no one is more ignorant than a parent when their youngsters are 17 or 18. So, his model of having youngsters do precisely what he would have them do is not always clear cut.

Senator KASSEBAUM. I would like to have Dr. Hinners, perhaps, respond to the short-term commitments because I saw him shaking his head vigorously when we were discussing this. Would you care to say why you are opposed to that?

Dr. HINNERS. I don't know if you noticed, but my head went all directions.

Dr. SPOONER. Typical administrator.

Dr. HINNERS. I don't think our basic problem is one of planning. It is commitment. And I agree totally with what was said in that we do need to make long-term commitments. But what has in large prevented us from doing that, it's not that we haven't been able to plan for long-term commitments, but we haven't been able to make that commitment. I think the multiyear authorization and appropriations would go a long way towards creating the stability in the funding so that then we can do that with planning, commit to step funding, three-year programs, five year. That indeed is part of the new university-space engineering plan at this point, to make this multiyear commitment.

We are looking more at life sciences I agree with your comments on life sciences, obviously a very important part of our upcoming program which needs to be given much more high-level attention, and competitively so. This is very stimulating, a lot of the things that came out of this hearing we will take back and work with. Thank you.

Senator KASSEBAUM. Okay. Just one more question.

UNIDENTIFIED SPEAKER. It might not be a question. I want to comment on the point, the question on History and Geography. Many people, I am afraid, are not aware of what's in our textbooks. A little over 10 years ago in the elementary level, and I'm a retired elementary teacher, and they took out the history as such and the geography as such from our textbooks. They teach now what they call Social Studies, which is a dab of this, dab of that, and kids come out without knowing any Geography and very little American History as such. Now, I think parents and people in general need to get involved with what's in the textbooks. The textbooks are entirely different than when you were in school and I was in school. It's just a totally different thing.

Incidentally, I might add that I taught aerospace in the classroom and with working at the university level for 25 years.

Senator KASSEBAUM. Thank you very much. And I would like to thank the panel, very much for a very interesting discussion.

The next speaker is Mr. Milton Sills, Director of Engineering, Cessna Aircraft; Mr. Richard Abbott, Principal Engineer, Advanced Composites for Beech Aircraft; Mr. Dennis Kizzier, Director of New Business Development, Learjet; and Mr. Gilbert Keyes of the Boeing Company.

It's a pleasure to welcome all of you. Mr. Sills, do you wish to go first?

STATEMENT OF MILTON SILLS, DIRECTOR OF ENGINEERING, CESSNA AIRCRAFT CO.

Mr. SILLS. Thank you, Senator Kassebaum, and Members of the Subcommittee. I do thank you for inviting me to participate in this

hearing. It's very exciting for me. I've been involved in aviation and excited with my involvement in aviation since the astronaut Joe Engle introduced me to my first flight instructor at Kansas University in 1953.

I am with Cessna Aircraft Company, so my comments will primarily be focused on aircraft as opposed to spacecraft, and in particular, general aviation aircraft.

Cessna is involved, of course, in the manufacture and service of aircraft, from the single-engine trainer up through and including high performance business jets which incorporate the most current technology available today.

The National research and development strategy in the last 25, 30 years has produced some outstanding successes in space exploration, and that is certainly as it should be, and it should continue. In the same time frame, however, we have done almost nothing in the development of basic aeronautic technology, and the results are becoming very apparent. The research that has been done in aeronautics has been directed primarily toward military aircraft and, to some extent, the large commercial transports. Very little has been done to provide the basis for new general aviation aircraft.

The National Transportation System needs more than large commercial jetliners, on the one hand, and automobiles on the other. I believe there needs to be much more National awareness of a vital need that is filled in our transportation system by some two hundred thousand general aviation airplanes. The technology has not been developed and is not being developed to support a modernization of this fleet. The technology that has been developed, most of which was prior to the 1960's and to some extent into the 1960's, has been extensively applied at Cessna and in the rest of the industry. But we need to renew our National focus on technology development of aeronautics now if the United States is to be competitive in the future. The best we can do probably for the near term is to be careful that we don't overreact to some of the hysteria over overcrowded skies but rather address these issues using a rational, technical approach.

In regard to how we approach aeronautics research and development from this point forward, I'd like to recommend that we encourage, through increased application of our resources, the cooperative programs of NASA, the universities, and industry. And these have been spoken of by some of the people who testified earlier. Cessna has participated in these. This gives the most research and development result for the dollar, I believe, and it also does some other things. It assures that the effort is directed towards applications that are the most viable and have the best opportunity for application. If industry, NASA and the universities together determine what is to be approached in terms of research and development. At the same time, the involvement of the university and the university students in these cooperative research and development projects does produce an improvement in the education of our university students. I believe this method has proved to be a very satisfactory way to approach research and development for aeronautics where we can share the resource that we have in the industry which may not be so readily available at NASA or the universities,

and also, each of these facilities can contribute where they have the best opportunity to contribute.

We also need to look in the long term toward providing advanced testing and simulator facilities sponsored by the government that will provide a cost effective availability to encourage aircraft industry to apply developing technologies to new products. Not only do we need to have a view toward much expanded and improved technology capability in terms of our testing facilities, but we need to have enough capacity and enough underwriting of the operation of those facilities that industry can participate more freely and to a greater extent and move the technology into the products more rapidly.

I do not disagree with most of the technology that's taking place or the fields that are being explored. The rate is what is in question, and that is limited by very sparse funding.

The comments have been brief. They're in which more detail in the written testimony. I thank you again.

[The statement follows:]

STATEMENT OF MILT SILLS, DIRECTOR OF ENGINEERING, CESSNA AIRCRAFT COMPANY

I will be presenting my observations and recommendations for consideration from the vantage point of the primary involvement of the Cessna Aircraft Company which is with airplanes as opposed to spacecraft. The Cessna Aircraft Company is involved in the manufacture and service of aircraft from the small propeller-driven aircraft through the high performance business jet aircraft incorporating the most current technology available in the industry. Our primary business at this time is turbine powered aircraft for the commercial business market and military jet trainers.

Our national research and development strategy over the last 25 to 30 years has produced some outstanding successes in space exploration. This has provided beneficial results for application to many products, including aircraft. Because, however, this strategy has focused so strongly on the technologies required for space exploration, those research projects needed to advance aeronautics for application to airplanes, particularly general aviation airplanes has been badly neglected. I certainly believe we need to maintain this strong emphasis on space technology but we must also recognize the need for a strategy which will provide the basic technology advancements to enable the development of new and improved aircraft. Practically all of the technology used in aircraft today was generated prior to the late 1960s. The lack of strategic emphasis on research in aeronautics has caused the country to lose the momentum we once enjoyed. The aeronautics research and development that has occurred in the last 25 years not only has been small but has been focused predominantly on the military aircraft and large, commercial transports. There has been almost nothing accomplished that had applicability to general aviation aircraft except what could be derived from the large transports and military.

I believe we need much more national awareness of the critical importance of general aviation. There is a vast need for business, as well as personal transportation, that cannot be filled by the large airline system and the automobile. There are 200,000 obsoleting general aviation airplanes that fulfill the transportation need between the airliner and the automobile. In addition, these aircraft fulfill many training and utility roles. These range from single-engine propeller aircraft to jets that fly higher than and as fast as commercial airliners. Cessna, along with the other general aviation manufacturers helps fill this vital role in our national transportation system.

Cessna maintains a continuing involvement with NASA and the universities, participating in research projects involving aircraft systems, aerodynamics, aircraft structure and crashworthiness. The results of these projects are normally very beneficial, if not in the near term, eventually leading to a beneficial result. We have extensively applied the results of research and development work when they have become available. The computer programs which have been developed for analyzing aircraft structure, and analyzing aerodynamic flow and aeroelastic characteristics have been extremely valuable to aircraft design. Cessna was the first to use the NASA developed supercritical airfoil technology in the design of a new airplane. We

have also benefited from the development of crashworthiness criteria for new product designs.

Research and development of turbine engine technology funded by various branches of the military has been very beneficial and has provided a basis for the most advancement we have seen in airplane efficiency. This must continue, and be accelerated. The work which has been done to develop prop fan and unducted fan propulsion concepts has been encouraging. We need to continue that exploration at an increasing rate and include the applications to small powerplants since scaling effects can be critical to the success in application. Unfortunately, exploration of aerodynamic and aero propulsion concepts in other areas has been agonizingly slow. Funding has been minuscule.

Crashworthiness research has produced a basis for some major benefits in seat design, toxicity and flammability of interior materials, but again this research was drawn out over many years because of very limited application of resouces—and the same lack of emphasis continues. The national commitment to aircraft systems research and development has been so small it is hard to identify a success in the last 20 years that could be applied to commercial aircraft. There have been major advancements in avionics in aircraft developed in the industry. Admittedly these have been helped considerably by space research. The need for modern digital data buss, the vastly improved anti-ice systems, for example, could have been fulfilled by now had concentrated research and development been appiled, beyond that which has been possible in the private sector. Many of these projects have been stopped, even though they show promise, because even the small funding has dried up. Electro impulse de-ice, laminar airfoil development, improved ride qualities, for example, have been terminated, greatly delayed or are about to be.

Airframe materials need much more focused attention. Some work has been done on a national level for large transport aircraft but that needs to be accelerated and also needs to be directed toward general aviation aircraft. The basic data base for new materials needs extensive work. The data for currently avialable materials do not permit the designs to avoid excessive conservatism.

Another area that must be addressed is the basis for certification of commercial aircraft. In many cases the criteria are excessively conservative because of a lack of a well developed rational data base. The requirements are, therefore, solidified very late in the design process, causing excessive costs and resulting in a product that is less efficient, more complex and, therefore, most costly to operate.

What needs to be done if the U.S. is to be competitive in the short term, mid-term, and far term? Obviously increased research and development now will not help in the short term. What we must do is to take care that we do not destroy what we have. The near hysteria at times over crowded skies and noise pollution must be calmed so that rational solutions can be achieved. In the mid-term years, probably the greatest benefit can be derived from funding research which is underway but which is progressing at a very slow pace because of the lack of funding. This includes extending the understanding of those technologies into smaller aircraft where scaling effects may cause the research being conducted at this time to not be applicable. In the far term, we need to develop a modernized testing capability for aeronautics such as advanced wind tunnels, test cells, crashworthiness facilities, systems test facilities and simulation facilities which are made available not only for basic research but to industry for applications development. The availability to industry should be on a cost basis that would encourage the applications of newly developed technology to the product.

One very good result has come from the limited government funds. That is, the cooperative, working relationship and resources sharing of NASA, universities and industry on research and development projects. Cessna has participated and still is participating in a number of these. This concept offers the most promise for a cost effective research and development effort. This approach provides a number of benefits that are not necessarily present when each segment operates as a separate entity. This combined effort gives the best assurance that industry will use the results, since we have our money involved. It also provides the most immediate understanding of the results, because our people are involved. We also tend to avoid those projects that are not recognized to have ultimate value. This provides the opportuntiy for improved education of university students in areas where they can understand the application of new technology more readily. This concept also addresses the total money that is needed from government funding. The condition we must correct, however, is the extremely low-level of government funding going into aeronautic research and development.

Senator KASSEBAUM. Thank you very much, Mr. Sills. Mr. Abbott.

STATEMENT OF RICHARD ABBOTT, PRINCIPAL ENGINEER, ADVANCED COMPOSITES, BEECH AIRCRAFT CORP.

Mr. ABBOTT. Good morning, Senator Kassebaum, and distinguished guests. My name is Richard Abbott, and I am the principal engineer in charge of advanced composites at Beech Aircraft Corporation. Beech is a subsidiary of the Raytheon Company and is a well-known manufacturer of products for business and military aviation. A summary of the company's business history are included in the submitted text.

Today, Beech Aircraft is leading the efforts to explore and pioneer the use of new materials, specifically advanced composites, and to adapt them to new aerodynamic shapes.

Advanced composite materials, consisting of fibers and fabrics combined with epoxy resins and cured under high pressures and temperatures, provide the designer with significant advantages over traditional materials. Among those advantages are weight savings, freedom from corrosion, resistance to cracking, and the ability to mold elaborate contours with great accuracy and smoothness.

The central thrust of our efforts has been the design and development of the world's first all-composite business aircraft, the Starship. The Starship represents more than six years of work and an investment of over 300 million dollars, all of it in funds raised from the private sector. It also represents the most advanced aircraft of its class in the world. In design methods, aerodynamics, digital avionics, advanced composite structures, and new manufacturing techniques, it is the state of the art. It is a prime example of the kind of program by American industry that's kept the United States in a premier position in aviation and aerospace.

But today we ask the question, "What must the United States do to maintain that position?" The answer may be that innovative programs, such as the Starship, can only continue to occur with the aid and stimulation from the public sector.

We would recommend four basic strategies. The first is to sponsor technology, ideally through joint programs, as we've heard about today, among major universities, private industry, and government. In organizing these programs, it is important to remember that the point of advancing technology is to create applications, commercial and military. In the case of demonstrated programs for commercial aviation, it is important that representatives of the Federal Aviation Authority be involved from the inception.

The second recommendation is to reward new technology. Reward can come in the form of tax incentives or training grants, as well as in contracts to buy high technology products. There may also be creative ways of accomplishing this that we have not yet identified. It is important to ensure that the company which takes the risk to advance technology has the opportunity to be rewarded.

Third, and this is crucial, government should employ that technology. My company's recent experience offers an excellent illustration of how this could happen. In the course of developing the Starship, Beech invested more than 145 million dollars in a state-

of-the-art composite fabrication facility. While it is still many months before we recognize a return by delivering Starships, we are earning a return on our composite facility today. We were recently awarded subcontracts from McDonnell Douglas and from Lockheed to design and manufacture composite hardware for the Air Force C–17 military transport. The technology Beech brings to the C–17 Program will make for a better final product than what otherwise would have been possible. The C–17 is an excellent example of how a government program can benefit from and help justify the massive capital investment necessary to create today's new technology.

But it is not enough for government to let this kind of activity occur by itself. There must be incentives built into the procurement process which favors emerging technology over older designs and concepts. It is essential to foster an atmosphere that stimulates development if we are to keep our lead against those nations whose governments are in fact financial partners with industry.

Our fourth and final strategy is this. The government should make every effort to ensure that open and honestly competitive markets are available to U.S. manufacturers, both domestically and internationally. It is not appropriate for the government to assume the role of procurer of all the technology generated by this Nation's industry. The world market is the appropriate place to sell the majority of the products.

In conclusion, the government has the capability to create an atmosphere which is conducive to the development of new technology. It does not have the capability to perpetuate a guaranteed market share for American industry in the technology that's being pioneered. Some erosion of the market share is inevitable as technology matures and overseas competitors increase their level of sophistication. The founders of the industrial revolution in England were undoubtedly dismayed to find the colonies making their own textiles, steels, and so forth.

In short, the way to maintain leadership is to create an atmosphere conducive to development and to make certain that the companies that come up with a successful development are in fact rewarded. Then, when markets are invaded by competition, the pioneering companies will be creating even newer technology, starting newer products and markets, a dynamic process which should never end.

Finally, keep in mind that the cornerstone of American technology success has always been in the innovative nature of free enterprise. But do nothing to upset that system. If you do nothing else but maintain the ability of the companies engaged in this industry to do business and operate at a profit, you will have supported the United States' position in aviation and aerospace. Thank you.

[The statement follows:]

STATEMENT OF RICHARD ABBOTT, PRINCIPAL ENGINEER—ADVANCED COMPOSITES, BEECH AIRCRAFT CORPORATION

Senator Kassebaum, members of the committee, and distinguished guests: I am Richard Abbott, principal engineer in charge of advanced composites, representing my employer, the Beech Aircraft Corporation.

Beech Aircraft, a wholly-owned subsidiary of the Raytheon Company, has been in the business of designing and manufacturing airplanes for the general aviation

market since 1932. We employ approximately 8,700 people worldwide, including more than 6,000 here in the State of Kansas. Last year our annual sales amounted to $699 million.

We are a diversified company, whose business lines include the manufacture of single and twin engine piston-powered airplanes in the owner-flown category, and twin engine turboprop and fanjet-powered executive transport aircraft. We also build aircraft for the regional airline industry, and we sell versions of our commercial aircraft line to all four branches of the U.S. military as well as to such federal agencies as the Forest Service and the Federal Aviation Administration.

In addition, Beech Aircraft manufactures subsonic and supersonic missile targets for use by the U.S. armed forces and various allied nations.

Beyond manufacturing, Beech, through subsidiary companies, provides contractor support to aircraft operated by the U.S. military at more than 200 locations throughout the world, and also operates a chain of 17 general aviation retail sales and service outlets throughout the continental United States.

In recent years more than 30 percent of our commercial business has been to customers outside the United States, and we have therefore made a significant contribution toward narrowing the trade imbalance which currently exists.

Beech also represents one of the few businesses in this country which is bringing jobs from overseas locations to factories here in the United States. We recently announced a program to transfer more than 350 manufacturing jobs now located in Japan to facilities here in Kansas.

The Beech Aircraft Corporation has played a significant role throughout its history in keeping the American aviation and aerospace industry on the leading edge of technological development. Beech airplanes, including the Staggerwing, Model 18 Twin Beech, V-tail Bonanza, and King Air to name just a few, are recognized around the world as milestone designs that advanced the state of the art in their fields.

Our reputation in areospace is also well established—Beech equipment has played a critical role in the life support systems aboard every U.S. manned space mission since Gemini.

Today Beech is at the forefront of yet another effort to advance the art and science of aviation—the program to explore and pioneer the use of new materials, specifically advanced composites, and to adapt them to new aerodynamic shapes.

Advanced composite materials, consisting of fibers and fabrics combined with epoxy resins and cured under high pressures and temperatures, can provide a designer with significant advantages over more traditional materials, such as metal. Among those advantages are weight savings, freedom from corrosion, high resistance to fatigue cracking, and the ability to mold elaborate contours with great accuracy and smoothness.

Industry and government have only begun to explore the full potential for applying advanced composites to commercial and military products. Fiberglass boat hulls are perhaps the most visible large-scale commercial application today, although most of these are cured at ambient temperature, without the benefit of high-pressure autoclaves. The term "advanced" applies to the higher-strength composites derived from high pressure curing—a procedure that is virtually mandatory in aerospace applications.

The central thrust of our effort in this area at Beech Aircraft has been the design and development of the world's first all-composite twin-engine turboprop light transport, which we call Starship.

The origins of the Starship program extend back to the late 1970s, when we began our first preliminary configurations studies for an advanced design aircraft to add to our commercial line. By mid-1982 we had defined what Starship would be, and were beginning the process to design, build and certify it. Today, four-and-a-half years later, we are close to achieving final certification, and our manufacturing facilities are now building the first production airplanes for customer delivery.

You can see that development of an advanced design aircraft in this class represents more than six years of work by an established organization with considerable expertise in building airplanes. It also represents an investment on the order of $300 million—all of it in funds from the private sector.

Starship is the most advanced aircraft in its class in the world at this time. In design methods, aerodynamic configuration, integrated digital avionics, advanced composite structures and new manufacturing techniques, it clearly represents the state of the art.

It also clearly represents a prime example of the kind of development program by American industry that has kept the United States in a premier position in aviation

and aerospace development since before World War II—a bold venture by private industry to advance the boundary of knowledge.

But as we ask the question: "What must the United States do to maintain the pre-eminent position in aviation that it has enjoyed for so long?", we may find that programs such as Beech's Starship effort can only continue to occur in the future with aid and stimulation from the public sector.

Specifically, we believe that the United States government must make every effort to create and nurture an environment which is conducive to technological development. Further, government's role should be defined in two distinct categories:

•First, what government should be doing, and what it can legitimately be expected to accomplish by doing it:

•And, second, what government should not be doing, and why not. This may be even more important than the first, because by doing the wrong things government can effectively poison the process of developing new technology, and make it impossible for progress to occur.

In the initial category—what government should be doing—I would recommend four broad strategies:

The first is to sponsor technology, ideally through joint programs among major universities, private industry and government. In organizing these programs it is important to remember that the point of advancing technology is to create commercial and military applications. To speed the process from test lab to final production, it is critical that representatives of the agency responsible for certifying the final product be intimately involved in the process from its inception.

The second is to reward the development of new technology by the private sector. Reward can come in the form of tax incentives and training grants, as well as in procurement contracts to purchase the product of technological development or their offspring. There may also be creative ways to accomplishing this reward, which we have not yet identified, but the important thing is to ensure that the company which takes the risk to advance technology has sufficient opportunity to be rewarded.

It is one of the great strengths of our nation's economic system that it spawns technological advancement in the search for profit. We must exploit this strength by providing as many opportunities as possible for companies to market their products. This is the formula which has kept the United States in a position of aviation and aerospace leadership since World War II. We should not abandon it now.

Third, and this is critical, government should employ the technology that is developed in private industry. My company offers an excellent illustration of how this can be done.

During the past six years Beech has invested more than $145 million to establish a state-of-the-art composite fabrication facility and develop enormous technical capability in operating it. Today we are recognized throughout the industry as one of the leaders in advanced composite technology.

We made this investment in the course of developing Starship. While it will still be many months before we recognize any return from selling Starships, we are already earning a return on our composite capabilities investment in the form of recently-awarded subcontracts from McDonnell Douglas and Lockheed to design and manufacture landing gear doors and winglets for the new Air Force C-17 military transport aircraft. These contracts hold the potential for hundreds of jobs for Beech over the next decade. At the same time, the technology Beech brings to the program will make for a better final product than would otherwise be possible. Taken together, this represents an excellent example of the kind of government-generated spin-off work which benefits from, as well as helps to justify, massive capital investment in new technology.

But it is not enough for government to let this kind of example occur by itself. There should be incentives built into the procurement process to favor the application of emerging technology over older designs and concepts. If we can create more applications for new new technology, we will promote the development of still more technology. Fostering an atmosphere that stimulates development is essential if we are to keep our lead against nations whose governments act as partners with industry in developing new ideas.

Fourth, government should make every effort to ensure that open and honestly-competitive markets are available to U.S. manufacturers of high technology products, both domestically and internationally. It is not appropriate that government should try to take on the role of prime procurer of all the new technology generated this nation's industry. The world market is appropriate space to sell the majority of the products of our advanced technology.

It is not realistic to expect that American companies will enjoy a perpetual monopoly in the areas of high technology they pioneer. Some erosion of market share at a given level of technology is inevitable as overseas competitors, hungry for a share of the pie, increase their level of sophistication. This is not a new trend. It has always been a reality of economic life. The founders of the industrial revolution in England were undoubtedly dismayed to find the colonies making their own textiles, steel, and so on. Maintaining a position on the leading edge of technology has never been easy. In today's complex environment, it is more challenging than ever before, and may only be possible with the cooperative effort of government, academia, and the private sector.

Now I will address a more controversial topic: the role government should not play if it wants to keep industry operating on the leading edge of technological development.

Typically the biggest impediment to the introduction of new technology in an established field is regulation—mostly because the regulation is written to deal with the shortcomings of the existing technology. The result is that when new technology is introduced, it must frequently meet requirements that aren't germaine to its specific properties, simply because the regulation says that it must.

This kind of thinking is particularly evident in military procurement programs, and tends to cause them to be biased against technologies which have widespread use in commercial applications. An excellent example can be seen in the U.S. Navy, which could not deploy fiberglass-hulled minesweepers in the Persian Gulf recently when many other nations were able to. The fiberglass vessels, which are much better suited to the minesweeping task than ships built with metal hulls, were rejected by the U.S. Navy largely because they wouldn't behave like metal ones.

A system with limited regulation can embrace change. One that is over-regulated tends to fight change bitterly. We must make certain that our government fosters systems which are receptive to change if we expect to continue as a nation in the role of technological leaders in aerospace or any other field.

We must also be wary of programs to stimulate technology which are defined too narrowly, and thus guaranteed to only produce advances within a limited range. As an example: The recent NASA Civil Aeronautics Technology Development and Validation Plan, which recommends investing $2.6 billion in new technology research, but excludes the general aviation industry, calling it an "advanced personal transportation system . . . not ready for large scale development effort based on competitive issues."

Clearly this is the conclusion of authors with a pre-loaded bias to favor the existing major players in a narrow segment of the industry. It fails to recognize that significant advances, such as Starship, are coming from other quarters, and that the advances made in one segment of the industry are readily transferrable to the other segments. The gains in technology aimed at general aviation products are almost always directly applicable to military or heavy transport aircraft, and vice versa. Technology is technology and hardware is hardware, regardless of the end user.

In conclusion, government has the capability to create an atmosphere which is very conducive to the development of new technology. It also has the capability to inhibit that development. This committee has a great deal of influence over choosing which kind of government programs our country is going to have.

On behalf of my company, I ask you to develop programs that will sponsor the development of new technology by private industry. I ask you to do it in a way that will not favor one aspect of the industry over another, and will not favor the very large manufacturers over smaller and more vigorous companies that might enter the field with a new, and perhaps better, idea.

Your programs should be tailored to reward and stimulate the companies which are producing results today, and are displaying proven capability to continue to do so tomorrow.

Finally, keep in mind that the cornerstone of American technological success has always been in the innovative nature of free enterprise and the quest for profit. Do not do anything to upset the atmosphere that allows that system to function. If you do nothing else but to maintain the ability of the companies engaged in this industry to do business and operate at a profit, you will have gone a long way to maintaining the United States pre-eminent position in aviation and aerospace.

Senator KASSEBAUM. Thank you very much, Mr. Abbott. Mr. Kizzier. Am I pronouncing that correct?

STATEMENT OF DENNIS E. KIZZIER, DIRECTOR OF NEW BUSINESS DEVELOPMENT, LEARJET CORP.

Mr. KIZZIER. Kizzier, that's correct. Senator Kassebaum, Members of the Science, Technology and Space Subcommittee, my name is Dennis Kizzier. I am Director of Business Development for Learjet Corporation in Wichita, Kansas. It is a pleasure for me to represent my company at this hearing today.

In early 1985, Learjet made the long-term commitment to become involved in the aerospace subcontracts arena by investing more than 6 million dollars in manufacturing equipment required to support this endeavor. This equipment included a huge, automatic riveting device, five-axis milling machinery, an automated process line, and robotic painting system. This equipment probably comprises the most modern and sophisticated equipment in the Space Shuttle Supply System today.

Since our entry into the aerospace subcontracting business in 1985, we have grown from less than 3 million dollars in annual sales to more than 30 million last year. We started with an initial customer base of just four aerospace companies, and I am pleased to report that our customer base today stands at twelve, representing nearly every major aerospace company in the country. This list includes the Boeing Company, Martin Marietta, Northrop, General Dynamics, McDonnell Douglas, as well as the United States Air Force. We enter 1988 with an aerospace backlog of more than 27 million dollars.

We feel that this dramatic business growth certainly was enhanced by two very basic but important factors. First, Learjet's reputation as a quality-conscious and innovative manufacturer; and second, the fact that Wichita is noted throughout the aerospace industry as possessing the highly technical and skilled work force necessary to support a man-rated program such as the Space Shuttle.

The first major contract obtained by Learjet was awarded by Martin Marietta Manned Space Systems. This contract involved supplying the main structural components for the external tank on the Space Shuttle System. The components supplied consist of eight large panels approximately 15 feet wide by 28 feet long that make up the intertank portion of the external tank and the solid rocket booster beam, the main attach point for the solid rocket boosters. This contract runs well into the 1990's and could easily result in the equivalent of hundreds of man years of work for the labor force in the Wichita area.

In regard to this contract, what is shown here, a completed external tank for the Space Shuttle System, I am pleased to announce that Martin Marietta has nominated Learjet for NASA's Excellence Award for Quality and Productivity. Everyone at Learjet is extremely proud of this nominaition and, as stated earlier, we feel this again attests to the quality of the labor force in Kansas and our ability to supply the flight hardware utilized on a man-rated Space Program.

The future of the aerospace endeavor continues to look very promising. In addition to our long-term contracts with Martin Marietta, we expect our existing contract to supply portions of the

Space Shuttle's external tank to be more than doubled in 1988, extending our production commitment to a total of 60 units running through 1995. By utilizing the technology and resource base established specifically for the Space Shuttle Program, there is every reason to believe that we will be an integral part of the Space Station manufacturing team as well as the unmanned launch vehicle or Shuttle-C concept that will be required in the support of SDI, or better known as the Star Wars Program.

As I said earlier, it is the synergism created between the corporate commitment and the available human resource that gives the Wichita area a competitive edge in the aerospace industry. However, regardless of the high-tech equipment commitments made by industry, it is and always will be the expansion of the human resource that makes this delicate balancing act, that of staying on the leading edge of manufacturing technology, work. Thank you. And Valerie, happy birthday.

Senator KASSEBAUM. Thank you very much. Mr. Keyes, maybe I should have been a little more specific. I just said the Boeing Company. You are President of the Boeing Commercial Space Development Company.

STATEMENT OF GILBERT W. KEYES, PRESIDENT, BOEING COMMERCIAL SPACE DEVELOPMENT COMPANY

Mr. KEYES. Thank you, Senator Kassebaum. The Boeing Company established the Boeing Commercial Space Development Company in 1987 motivated by the belief that the advent of the Space Station would lead to an outflow of invention and discovery which in turn would provide an increase in demands for space products and services related to Boeing product lines. We believe that it may well be in the later 1990's before this new company can achieve a major status among the Boeing family. However, we're convinced that if we are to become a profitable participant in space commercialization, now is the time to build a basis for such participation. Boeing has a commercial heritage, and the development of our new company can be compared to the early stages of the development of a new aircraft in which the expectation of profit is a number of years after the new project begins.

The future of our new company is linked to the U.S. Civilian Space Program, and in particular, the Space Station and to progress in related high technology areas. Clearly, NASA will lead the way in these areas, and properly so. The National Aeronautics and Space Act enabled our country to bring together the resources to make great strides in space and aeronautics technology and to be very competitive in these areas in world markets. Thus, the Space Act itself has provided a foundation on which U.S. commercial space activity could be built.

To assure that our country and its companies, such as the Boeing Commercial Space Development Company, are competitive in the future space and aeronautics markets, we must maintain the momentum in high technology that has become associated with NASA. In this regard, it's important that Congress establish basic broad goals for NASA and maintain them with the proper funding levels. Frequent changes of direction and emphasis make progress

more difficult and costly. In the 1970's, the Senate Authorizing Committee attempted to initiate a policy of establishing a constant level of funding for NASA but corrected for inflation. The idea of this was to let all involved know what funds would be available over a long period of time so that systematic planning could be done and progress maintained. Considerable discussion with the scientific community convinced the Committee that this was an important contribution that they could make. Discussions with budget authorities attempted to identify a level of funding that was sustainable. The concept was not carried over into the 1980's. Perhaps, however, this concept should be reconsidered as a way of establishing and maintaining U.S. momentum in space and aeronautics high technology.

The Space Station is, as I've said, of major importance to the Boeing Company. We recently won the contract to design and build the modules that comprise the U.S. laboratory and living quarters for the astronauts and the logistics systems. This contact which is known as work package 1 is the responsibility of the Marshall Space Flight Center in Huntsville, Alabama. We were particularly interested in this area of responsibility because it appeared to us that there would be opportunities to participate in the growth of the Space Station as additional requirements developed. We believed that this would be true since the Station could be expanded by adding modules. Additionally, we felt that there might be some commercial potential as the need for commercial laboratory or manufacturing space developed.

The Space Station is, of course, of great importance to the United States in maintaining its momentum in high technology. One of the important functions of the Space Station is it provides an absolutely unique laboratory where the physical laws and effects of near earth space can be used to speed the process of invention and discovery. In this regard, it's similar to the early development of wind tunnels. Wind tunnels were designed to speed the process of invention and discovery in the physical laws and effects of high speed air flow. Like the Space Station, there was some that were very concerned about the large expenditures in an area where the need was, at that time, questionable in the minds of some.

An important feature of the Space Station is that it will be manned. Thus, scientists can conduct experiments and observe the results and rapidly go on to the next experiment based upon the results of the previous one. Not only will the process of invention and discovery be speeded by the manned feature of the Space Station, but also the accidental discoveries that would be missed if man were not present would be observed.

The history of industrial development is significantly a history of materials technology. Our ability to devise new inventions depends on our ability to create materials with enabling properties. This has been particularly true in the aerospace industry where our vehicles depend on high strength, lightweight structural materials. It's also been true with the emergence of our entire electronics industry which has been built on the special properties of semiconductors. These two examples are cited, because when the history of the Space Station is written, it appears that its greatest contribution may well be in the area of materials research. In microgravity,

scientists may be able to better understand the process by which metals freeze, by which certain crystals grow, and other phenomena that are a key to the production of commercially important materials. This information may enable the processing of better materials on the ground as well as the production of some superior materials in space.

The early research work that this country has done in space has pointed toward possible uses for the Space Station and possible discoveries and developments which may be made there. However, the greatest discoveries which will be made on the Space Station are probably things we haven't yet considered. Speculating on discovers and developments for the Space Station are like trying to predict what Mr. Thomas Edison would discover based on the way he outfitted his laboratory. Even he could not have predicted the direction that his research took him. The Space Station will enable modern day Thomas Edisons to continue their tradition in the absolutely unique environment of near Earth space. Just one discovery that enables us to change our ground based processing and significantly improve the strength and characteristics of common material such as aluminum, cast iron or the like, could have a long-term economic value which might be equal the entire cost of the Space Station project. Maintaining the Space Station is a major contribution to maintaining U.S. momentum in high technology. Thank you.

Senator KASSEBAUM. Thank you very much. I have a couple of questions for anyone on the panel to answer. Have you made projections about future labor needs, both in terms of quantity and quality? And as another aspect of that, has the decline in the general aviation industry over the last couple of years affected the pool of skilled labor and some of the needs in this area? Who wants to go first?

Mr. ABBOTT. Can I make the first comment on that? We have been using training grants in fact to train a new pool of skilled factory type labor in new technologies, such as composite materials, and we see this as an essential and progressive device.

In view of the somewhat, shall we say, harsh comments from the academic panel this morning, I don't share some of those concerns. The new graduates, Bachelor, Master's level, in my opinion, they're terrific. Scientifically, they are very well equipped for our needs today. I don't see some of the problems that we're annunciating.

Now, the question of being well rounded and knowing how to put your finger on Indonesia, I see that as on a different scale. And, yes, some nations such as the European Nations just naturally will be more into those things.

Senator KASSEBAUM. Where did you get the training grants you are using?

Mr. ABBOTT. I should know but I don't.

Senator KASSEBAUM. I was just curious if it was some part of our grant funding in the Federal Program——

Mr. ABBOTT. What kind of grants were the training grants for the training?

UNIDENTIFIED SPEAKER. I was under the impression it was Federal, but it may have been a combination of Federal and State.

Senator KASSEBAUM. I would guess it might be Federal because we do have the retraining grants. Maybe this is more in your area, Mr. Keyes, but anyone that wants to can answer this. The President's new commercial space initiative is reflected in his leadership and commitment, yet, what do you as a contractor require from this commercial space initiative to justify your investments?

Mr. KEYES. Mrs. Kassebaum, the President's initiative gives emphasis to the area of commercialization. But in terms of specific incentives, I think that we've got a lot of work to do. I'll give you an example. We're looking at some specific areas of commercialization related to the Space Station project. However, it appears that before commercial sales can be made that we must develop our specific proposal and then provide that information to NASA so they can then go out and compete it. And I don't know how much preliminary investment will be required by industry before the competition. I think that the challenge now is to take a look at the overall procurement process to see how we can revise procurement process to make the President's initiatives in commercialization effective. I think there's a lot of work that has to be done before the President's commercialization initiative will work.

Senator KASSEBAUM. Could you or anyone else outline some examples of public-private cooperation in research and development that have produced some significant results? All of you, I think, have probably been involved in that.

Mr. KEYES. One example is a program that was initiated a number of years ago in the aircraft fuel efficiency area. NASA had a major program to improve the fuel efficiency of aircraft at the same time that industry was extremely interested. Fuel efficiency would make aircraft very attractive for sale. I think that the two programs, that of NASA and that of industry, were really self-supporting. NASA did very advanced state-of-the-art technology work and industry then worked on the product related areas in aircraft fuel efficiency. I think that it's a NASA role to work at the leading edge of technology and it's an industry goal to then adapt that to products that we sell. I think that program achieved its purpose.

Mr. SILLS. I think there are some other examples that we've availed ourselves of. For example, I think we have improved the overall design capability of aircraft through the development of some of the more sophisticated computer analysis programs, for structures and aerodynamics. That has greatly facilitated the design process. The other more specific hardware examples, of course, that comes to mind are the development of the super critical wing, which has, moved right into our products. Some of the work which has gone on in the propulsion area, and particularly in turbine propulsion, has come out of the development of improved components in turbo-fan engines. Some of that, of course, came out of the military initiative, but that has also benefited the commercial world. We see other things underway, and some of this was alluded to earlier, in terms of anti-ice system development and so forth. These things have been an encouragement and helpful. However, they have moved at an excruciatingly slow pace sometimes, it seems to us, because of the low level of resource that's been able to be applied. But those things have been a direct carryover.

Now, the other things that we see coming straight out of the Space Program, have also helped electronic developments, not only in providing the tools needed here in the community but also for the advancements in cockpits, in cockpit displays, and changes in the way in which the crew are able to function more efficiently. There are a number of very good examples that have come out of the Space Program.

Senator KASSEBAUM. Mr. Keyes?

Mr. KEYES. There's another area that I think could improve that cooperation, and that's in the area of prototypes. Mr. Schartz talked about showing the models and demonstrations to high school students. Very sophisticated adults and companies are not too different from high school children in their interest in actual prototypes which utilize this very, advanced technology. It may not be practical for any individual industry, to build the prototypes, but it certainly builds the interest in industry in utilizing new high technology developments. I think that that's an area that we should increase government expenditures.

Mr. KIZZIER. Let me interject something here. Back during the great Space Race, I had a privilege of working with Rockwell. I was on the Apollo launch team. At that time, I was selected by NASA to work on a program that was called Speak Up For Apollo. And at that time, I traveled all over the United States extolling the benefits of the Apollo Program to the general business community, to universities, state bar associations, business conventions, and things like that, what they were getting out of the billions of dollars that we spent on the Apollo Program. And I think, looking back on it today, I had a script, and I certainly couldn't foresee the benefits that came out of that program, but I certainly didn't tell any lies and, if anything, I certainly underestimated the impact of that program on the future of this Nation and the future of the world.

Senator KASSEBAUM. Well, I think that is important. I think as a public today we all assume that we will continue to be the leaders in space—that we were there first and we will continue to be the leader. We take a lot for granted. It has become just a day-to-day understanding. Perhaps that speaks to not understanding well enough the advantages that accrue to us in our daily lives from this type of space exploration and the advancement of those technologies. Let me ask, what are the current trends, both in public and private efforts? You can speak more to, I'm sure, the private efforts. But I'm interested in the coordination efforts that exist there. And, is spending increasing? Are each of you targeting more of the company's money to R&D efforts? What is the nature of the coordination between the public and private sectors?

Mr. SILLS. I can comment on that very briefly. With the very dramatic change in the general aviation industry, it has been increasingly difficult to apply the quantities of resource to R&D that we would certainly like to apply. We have still maintained a percentage of our income for that purpose in the face of the dramatically reduced income levels. But it is much more difficult, if you will, to find the R&D dollars in this industry, that is strongly affected by the general aviation market.

Senator KASSEBAUM. Does the Cessna Company, for instance, target certain areas for its research and development dollars? I assume you do.

Mr. SILLS. Yes, we do. There's a little understanding that needs to be laid before I answer that specifically. We view ourselves primarily in the role of taking basic research information and then applying development energy; taking that technological base and converting that into product. We have not historically been able to apply much in terms of resource, to basic research and the development of a data base. So, what we have targeted for a future course includes an emphasis on propulsion systems, as well as the utilization of new materials in the airframe structure. Those two elements probably command more of our focus than some of the others, although systems do become heavily involved as we start to integrate the machine. There is very strong need for, if you will, the lower end of the general aviation industry, for propulsion. Turbines have received a lot of emphasis. Not much else has.

Senator KASSEBAUM. Can any of you speak to what foreign competitors are doing in this regard and how do they differ in handling research and development monies? How do they identify what areas should be targeted?

Mr. ABBOTT. May I comment first?

Senator KASSEBAUM. Sure.

Mr. ABBOTT. One of our concerns in the aviation industry, and this applies to both the companies of Beech and Cessna and part of the industry, as well as the Boeing end of it, is the competition from overseas nations where in fact government, academia, finance, research, industry, are essentially all brethren. This was illustrated when I went to Amsterdam last year, in that I was scheduled to make a lecture one afternoon, and the night before permission was requested to invite people from other areas, from National Research Laboratory, from Delft University, and so on. And I said, sure, go ahead. And with several phone calls, you know, overnight, all of those people were there, because they are all brethren. It's all the same organization. So, we're worried about competition from a formidable opponent. Once they set their targets on a certain market share, that's hard to compete with.

Senator KASSEBAUM. Should we do more of it that way in this country?

Mr. ABBOTT. Well, I think we are equally scared of the same sort of, you know, socialist type leading. We are deathly afraid of that, too. But there are areas where I deliberately avoided the word subsidy. All right. What I said was sponsorship.

Senator KASSEBAUM. I like that.

Mr. ABBOTT. This is a play on words maybe, but there are subtle differences there. What we're talking about is the type of program that is the focus of this hearing.

Senator KASSEBAUM. And you are right. There is a lot of confusion about privatization. Of course, the word we are using a lot now, particularly in terms of the Industrial Space Facility, is privatization. Well, it really is not. It is more government sponsorship. And I think we ought to understand that. That doesn't mean that it should not be done, but I think it helps us if we understand and recognize the dynamics that are involved. And I would argue that I

think a partnership is important between government and business and the universities. I think it's a triangle that perhaps we have analyzed carefully enough. Thank you. Does anybody have anything else?

Mr. KEYES. I would comment that the Japanese in the space area, have a partnership of government and industry and they proceed by a series of five-year plans. They identify what different companies are going to do and what the government's going to do. This has served them very well and moved them ahead very quickly. The Japanese are making tremendous strides in this area of space commercialization, with products, launch systems, and everything else.

Senator KASSEBAUM. And the robotics.

Mr. KEYES. Yes, very much so. I think it will serve the country of Japan very well and is going to make them tremendously competitive with us.

Senator KASSEBAUM. Thank you very much. You have been an interesting panel. I suppose we can say that we saved the best for last. It is a pleasure to welcome the next panel. Now gentlemen, you will have to prove that you are the best panel. Captain Jon McBride, who's NASA's Assistant Administrator for Congressional Relations, and Kansas' own Dr. Steven Hawley, certainly a shining example of the very best and the brightest of our Kansas students and a graduate of the University of Kansas. Welcome. Dr. Hawley, do you wish to go first?

STATEMENT OF DR. STEVEN A. HAWLEY, DEPUTY CHIEF, ASTRONAUT OFFICE, LYNDON B. JOHNSON SPACE CENTER

Dr. HAWLEY. Thank you very much, Senator Kassebaum. I would like to thank you for allowing me to be here today. I appreciate the invitation to come back home. I also appreciate the interest shown by you and the members of your staff in education and perhaps specifically in NASA's role in encouraging the study of science and technology among today's students.

We have already heard from many of the panelists today a concern that the United States is producing fewer graduates in science and engineering. If you would permit me, I would like to share with you some personal observations and reflections based on my experience.

There's no doubt in my mind that fundamental to the development of a generation of students who are comfortable with and conversant in science and technology is individual motivation. Indeed, that would seem to be the key in the individual development of students in any discipline. In my judgment, NASA can play a significant role through the excitement that we hope we engender in young people by virtue of the activities in which we are involved.

One of the common questions that I'm asked as I have an opportunity to travel around and speak to groups is, "Did you always want to grow up and be an astronaut?" When my father was a student, the word "astronaut" didn't even exist, and it was not until I was in school that we even knew what an astronaut was. Even then it wasn't a job that a kid growing up in Kansas could want to

grow up to do. In fact, prior to John's and my selection in 1978, NASA hadn't selected astronauts for nearly a decade. When I was in school, that meant that, realistically, the opportunity to aspire to be an astronaut didn't exist. Nowadays, NASA envisions regular selection of astronauts. And so kids going to school today will know that if they want, they can prepare themselves with some reasonable assurance that at least they will have the opportunity to compete for selection.

When I was a boy growing up, it was a special teacher and dark night skies in central Kansas that developed my interest in astronomy. As I recall the events, it was third grade and we had an assignment to draw a picture of the solar system, and I, how shall I say this, I got less than an outstanding mark on my project, and I was irritated. And I decided right then that I was going to show this teacher that I did know something about astronomy and the solar system, and so I went to the library on my own and began to read books on astronomy, and that's where my interest developed. Years later, I learned how important this was, although I didn't appreciate it at the time. How do you get kids interested enough to go read on their own? My interest in astronomy and astrophysics dates back to that episode in the third grade.

The next year when I was in fourth grade, the United States began to put people into space. I remember asking the teacher at that time if it would be okay if we brought a transistor radio to class so that we could listen to Alan Shepard's flight aboard Mercury. She said that would be okay. I remember it even now as though it were yesterday. It's still one of my most vivid memories.

As the American Space Program progressed, I became more and more interested in following the exploits of the astronauts. My curiosity was naturally aroused and I wanted to learn all that I could. I was probably sick a few days coincident with there being some missions on television, and I took pride in the fact that I was able to learn more about the Space Program than the other kids in class. And I had some questions that nobody could answer. I wondered why the first manned Gemini flight was called Gemini III. Why wasn't it Gemini I. I wondered, if the Mercury rockets have rocket escape towers, why don't the Gemini have some type of escape towers. And I was motivated to find out.

Most Americans can remember where they were when Armstrong and Aldrin walked on the Lunar surface. I remember where I was and what I was doing when Neil and Dave Scott got in trouble on Gemini VIII after docking with an Agena and had to do an emergency reentry and landing. As it turned out, I wasn't smart enough at the time to know what I was talking about, but that was my first exposure to flight rules. Flight rules make up a large part of what I do now.

There's no doubt that my interest in science was nurtured by our Space Program. Still, as I mentioned before, there was no chance that I could become an astronaut. All the astronauts were test pilots. Some day, however, I figured that we would want to do astronomy from space and that would be motivated principally by two conditions. First of all, the light pollution that is taking place around the major observatories on the earth; and second, the mere fact that the atmosphere is opaque to light wavelengths that con-

tain interesting physics. There's scientific reason, of course, to go look at objects in spectral regions that are not accessible from the ground. Some day, I reasoned that we would have some sort of an orbiting platform where we would be studying the universe through astronomy and we would need trained astonomers who were in reasonably good health and who were willing to undertake the challenge of going into space to do those observations. I didn't know it at the time but that's essentially what we now in NASA think of as a payload specialist, a scientist whose presence aboard a space flight is for some specific mission objective, some specific experiment, or scientific undertaking for which he has unique training. I never, honestly never figured on having a chance to be a career astronaut.

I graduated in 1969 from Salina High School. Unfortunately, that's long enough ago now that it's Salina Central High School. That was back in the days before there were two. You were kind enough to point out that I went to the University of Kansas. I felt an obligation to mention that this morning. I guess that was back in the days when there were some quality undergraduates. It might be of interest to the audience that all three Kansas astronauts, myself, Joe Engle and Ron Evans, all graduated from the University of Kansas. I got degrees in Physics and Astronomy, wanted to go on and get a Doctorate in Astrophysics, which wasn't available at the University of Kansas, and therefore I was forced to leave. I went to the University of California and got a Ph.D. in Astrophysics in 1977. By coincidence, at that time, when I was finishing my degree work, NASA began soliciting applications for the Space Shuttle Program. That was honestly the first time I had really thought that the opportunity to be a career astronaut might exist. And although it had not been a goal of mine, I realized that I had the qualifications, at least to the extent that they were stated on the brochure that NASA had provided, that I might be competitive, and so I went ahead and applied. Good fortune was with me and I was lucky enough to be picked.

What does all this experience now have to say about the subject of NASA's role in the scientific education of our young people? Well, first, it says to me that as a student, one needs to be prepared as much as possible to be in a position to take advantage of unforeseen opportunity. I hadn't planned to become an astronaut, but the opportunity presented itself and I was in a position, by virtue of my preparation, to be able to go for it. There are other astronauts in the office who were scientists or pilots with no expectation of being able to participate in the Space Program who, by virtue of their own individual initiative, had postured themselves to take advantage of opportunity when it was presented.

Second, NASA is inspirational. It certainly was to me when I was a kid, and I think it is today to our young men and women. In Dr. Hinners' testimony, he makes a point about the problems that NASA faces in competing with the private sector for outstanding science and engineering talent. One of the factors I think which enables us to attract the good people that we do is that truly people want to work for NASA. I don't mean just the astronauts, but all of the people with whom we come in contact are there because they want to work for NASA. I think they're inspired by its tradi-

tion, they're inspired by its accomplishments, they believe in its mission, and we all think that what we do is important to the country.

I believe that our young people have these feelings today as I did 20 years ago when I was in their position. I hope they do. Perhaps we can still inspire individual initiative and instill an interest in science and technology. I have personally tried over the years to share some of the excitement that I find in the Space Program with the people of Kansas. Part of NASA's original charter calls for public dissemination of information about what we're doing and what we've learned, and we take that obligation seriously. In the last two years I went back and made a count, and I've made about a dozen separate trips to Kansas with the hope of engendering in some young person the same sort of enthusiasm and motivation that I developed in grade school.

Additionally, in 1984, with the help of Former Secretary of State Jack Brier, I flew about 1900 small Kansas State flags with me on the Space Shuttle Discovery, and after the flight, we had them prepared on a little presentation plaque with a picture of the Space Shuttle and we gave them out to all of the school districts in the State with hopes that the kids in school would see these things and be inspired and see it as symoblic of what young men and women in Kansas can grow up to do. Even as when I was a kid, I didn't know what a Space Shuttle was when I watched Ed White do America's first spacewalk, today's students may not realize the excitement that awaits them in the decades to come as America continues to develop our foothold in space.

As you heard earlier this morning, Project Pathfinder will develop and demonstrate new technology that will be fundamental to our becoming a true space-faring nation. Today's students will be tomorrow's astronauts, flight controllers, design engineers, and systems experts, who will eventually make these proposals into reality and carry our Nation outward beyond low-Earth orbit.

Finally, I would like to acknowledge that Kansas is indeed fortunate to have some very special facilities and some very unique people who work with NASA to motivate our young people. Right here in Wichita is the Challenger Hall located at the Omnisphere. I was privileged last November to be asked to participate in its dedication, and since that time, it's provided a place for students to learn about science through a variety of interesting and informative hands-on experiments. Additionally, Kansans are extremely fortunate to have a facility like the Kansas Cosmosphere and Space Center in Hutchinson. The Cosmosphere director, Max Ary, who's here today, and I thank him for his attendance, he and his staff worked hard to bring the excitement of the Space Program here to Kansans through many wonderful exhibits, featuring real space artifacts. They've done a marvelous job of collecting together some of the things that we have flown in space. And I was privileged to be able to donate some of the material that we had on our flights to Max for display. The Cosmosphere is also one of the few facilities in America equipped to show the IMAX movie "The Dream is Alive." "The Dream is Alive" is a movie that we filmed aboard the Space Shuttle flights in 1984 in large format film which is projected on a planetarium dome which provides a panorama that's the

next best thing to being there. In fact, it's so exciting that I've seen it about two dozen times myself. I had a trip to the Kennedy Space Center several weeks ago with a free morning and I went over to the visitor's center and paid my 4.50 and went in and saw the movie again. It's tremendously exciting.

The Cosmosphere also operates a space camp, complete with simulators to allow the students to feel and think like astronauts. And I don't know the exact numbers, but I know from talking to Max and his staff that they have many more interested students than they have the resources to support. For the last several years, their advanced campers have had the opportunity to come down and visit us at the Johnson Space Center, and it's been my privilege at that time to meet with them and show them some of our facilities and talk with the advanced campers about what it's really like to be in space.

The educational staff of the Cosmosphere also offers the Teacher Training Program to provide interested teachers with a background on the development, current status and future of our Space Program. The hope is, of course, that they will then be able to effectively pass this information on to their students who will be involved in tomorrow's space adventures.

I would like to conclude with a message that was recently sent to me by Helen Unruh, one of my friends on the staff of the Cosmosphere and Space Center. She told me that she was giving a workshop to a group of sixth graders and they were discussing the benefits they had derived from the Space Program, much as we have discussed here this morning. One of the boys had something that, I think, makes us realize what a profound effect our efforts can have on our young people. He said, "If we didn't have a Space Program, kids like us wouldn't have anything to dream about."

I appreciate the opportunity to come here today and share these thoughts with you.

Senator KASSEBAUM. Thank you very much, Dr. Hawley. And I neglected to say you are now Deputy Chief of the Astronaut Office at Johnson Space Center. You are certainly an outstanding spokesman for all that is best in the space program, and we are really proud that you are a Kansan. And I'm glad you talked about the Cosmosphere because I think it is a unique contribution in Kansas. I would like to recognize Max Ary and Pat Carey, who are here. Both have been instrumental in building this and seeing it progress to the great service it provides to students and adults in Kansas.

Dr. HAWLEY. Thank you. It is a marvelous facility and Kansans are very fortunate to have that here.

Senator KASSEBAUM. Captain McBride.

STATEMENT OF JON A. McBRIDE, ASSISTANT ADMINISTRATOR FOR CONGRESSIONAL RELATIONS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. MCBRIDE. Thank you, Senator. It is indeed a pleasure for me to be here today. Steve has always told me that, in 10 years of the flights, that the sun always shines in Kansas. I believed that until the last day or so.

Dr. HAWLEY. Never windy either.

Mr. McBRIDE. Right, the sun always shines and it's never windy. It's very difficult for either of us to limit our discussions to 5 minutes or 10 minutes on space. I could spend hours on my mission alone. I'm sure Steve could do the same thing, but we are going to try to do that for you.

Before I go much further, I would like for someone to stand here who we haven't recognized. Our director of our Educational Program is very responsible for all these things that we do over at NASA, Dr. Bob Brown. Please stand. We owe a lot to Bob and for what he's done for our Educational Program.

I'm kind of in a unique position here this morning. I have had a chance to listen to everybody talk, and I made some notes here that I'm going to try and strengthen on some of the points that were made and fill in some of the other gaps. Of course, we are here to talk about education and research and development and how all that ties together to make us a stronger Nation with regard to space and aeronautics and all those good things, and aeronautics is a key word to NASA. I truly believe in that.

I'm a Navy pilot by trade. A lot like Steve, I grew up in a small town, only it was a little state we called West, By God, Virginia, a few miles from here. But I do remember those driving forces that Steve so eloquently alluded to. I'm a little bit older than Steve, respectively older than Steve. I was one of those folks who did grow up with the aspirations of being an astronaut. I was excited by the Space Program. In 1957, when Sputnik was launched, I was almost a high school person in those days. So, the headlines of those days and the opportunities that we could see on the horizons with regards to space were instrumental in furthering or optimizing or tailoring my career. I was driven by that, those exciting days of those first days in space of Sputnik in the late 1950's and early 1960's.

The one thing I do remember and I have to relate to is the quality of education that I felt I got from my little hometown of West Virginia. I could sense from every teacher I had, from the first grade through finishing high school and entering college in West Virginia University, there was a sincere interest in the welfare of John McBride and his classmates. I hope that's something—I feel that we have lost some of that over the last few years. I hope we can get that back, that sense of pride in seeing students wanting to do something good. I felt that for the whole 12 years in the private school system in West Virginia.

It drove me into pursuing an aviation career. I joined the Navy, became a Navy test pilot. I applied, along with Steve and thousands of others in 1977, to become an astronaut, and among the lucky few in 1978 chosen to come down and fly the Space Shuttle. And it's a credit to that selection system, NASA selection system, that all 35 of us who joined in 1978 did fly the Space Shuttle. So, that's something we can all be proud of there.

I was fortunate enough to fly the Space Shuttle Challenger myself in 1984 as the pilot for an eight and a half day mission in space. Of course, it's the most exciting thing that's ever happened to me in my life. I was due to be the commander of the flight that would have immediately followed the tragedy in 1986, loaded with scientific opportunities for an astromission. We were going to take

a payload full of ultraviolet scanners and look at Halley's Comet and hundreds of other unique opportunities throughout this universe of ours. So, of course, the tragedy in 1986 brought all of that to a tragic and serious halt. We've been on the ground now for two years, and will be another six months. It's been a terrible tragedy for us, Steve and I personally. It's been a terrible tragedy for NASA. It's been a terrible tragedy for this country. But it goes even further than that, it goes around this globe of ours. We were in a position in those days where our allies all around this globe of ours were dependent upon America and our Space Program. We need to get back in the air and get back into space just to unify that opportunity that we were capitalizing on, I think. We were using space in an effort to unite this globe of ours, to bring us closer together. And we had some unique programs, including Flying the Teacher in Space, we had a Journalist in Space Program. I am one of those folks that believes in this type of thing. I hope one of these days we can get them all back.

My prior, my current assignment at headquarters as a Director of Congressional Relations gives me the unique opportunity to blend this operational experience with the political climate, and it's an interesting one.

You've heard a lot of the things that are facing us this morning, including the budgetary problems that we're all facing.

I think we heard earlier that for every dollar you give NASA, you get five dollars back. That may be somewhat inflated, but even if it's two dollars back or three dollars back, I don't think there's a person in this country that would complain about getting two dollars back for every dollar that they invest in anything, and I truly believe in that.

Our budget, as Senator Kassebaum alluded to, is .93, less than 1 percent of the National budget this year. It has been as low as .7. That .93 figure is if we get the total budget that we have requested. If we don't, it's going to be down to the .7 area again. We feel like this is a juncture in the history or our Space Program, and our research and development and technology, that if we don't get this budget that we have requested this year, the science and research and development and indeed the Space Program will be in a critical situation. Whether it survives or not is a very good question. So, we are out there fighting for every dollar for NASA's budget this year and we certainly would request your support in that effort. We need it.

A couple of other notes here before I shut up. We heard a lot about spinoffs a little bit earlier, the fact that there been have been 30 or 33,000 of these things documented. You heard of some of the bigger ones. You didn't hear maybe that in 1960, it would have taken a room this size to build a computer, or hold a computer now that we can carry around in our hands. That's a direct spinoff of the Space Program. The fact that you can sit here in Wichita, Kansas and in a matter of 8 to 10 seconds dial anywhere in the world for about one-twentieth of the real cost that you could do it 20 or 30 years ago, assuming that you could get someone across the other side of the world, is a NASA spinoff. The fact that you can view TV and you can see live broadcasts of situations on the other side of the globe in real time is a NASA spinoff. How do you equate

the fact that we perhaps have saved, through our weather satellites, tens of thousands of lives over the last 20 years by getting people out of the way of hurricanes and tornadoes and bad weather. We have lost, in the history of this world, tens of thousands of lives in one massive hurricane or typhoon. We haven't had that type of situation in America since the onset of weather satellites.

How do you put a price on being number one in the world in research and technology? How do you put a price tag on that? We are not there any more. We are losing it very quickly. We have gone through a very serious two or two and a half years now of what I term NASA bashing. It's turned into battering almost.

I would like to leave with a couple of thoughts. I don't think there's any other agency in this government of ours that could have withstood what I call microscopic scrutiny over the last few fears and survived. I think any other organization in this Federal Government of ours would have rolled over and been dead and buried. Had we not had leadership, had we not had goals, had we not had some of the most intelligent minds in the world, the best infrastructure of our centers around this country of ours, we would not have survived. I think that's a credit to NASA.

We, all of us, Dr. Brown, Dr. Hawley, Dr. Hinners, Mr. Povinelli, everybody else at headquarters and throughout this system of ours around the country are dedicated to education. We see education as the future of this country. We're in the brain business, so we can't do anything at NASA without brains, and we feel like the youth of America is the future of this country, and the future youth of this country is in the brains and their education. And I don't know what else I can say. I could preach for days on this subject. I really do believe that we are at a juncture this year in the history of our research and development of our Space Program and we've got to go out there and make this thing work. It's going to take—it has to take a leadership directive from the top in this country to make this NASA budget work this year. If you think it's going to be tough this year, wait until next year or the year after. So, I think that 1 percent, in my mind, if we were to dedicate 1 percent of our total budget to research and development for the next 10 years, would be a small price to pay for that.

Thank you, Senator.

Senator KASSEBAUM. Thank you very much, Captain McBride. I don't believe I have any questions because I think both you and Dr. Hawley have really summed up what this hearing is all about. You brought to it the very best in your talents, and you in turn are going out and seeking new talents. And I've heard Dr. Hawley speak, and it's wonderful to observe the enthusiasm he generates by telling his stories. So, I think it's a good way to conclude.

Kansas has had its Stearmans and Beeches and Wallaces, and Bill Lear. All have been pioneers in the field of aviation, and I think Kansas has a unique role to play in the future as we move further and further into space. And so, for all of those who participated today, thank you very much. For those who came from Washington, we greatly appreciate your being here. And that concludes the hearing. Thank you very much.

[Whereupon, at 12:40 p.m., the Subcommittee was adjourned.]

[The following information was subsequently received for the record:]

STATEMENT OF ROBERT BRADFORD, EXECUTIVE DIRECTOR, WICHITA ENGINEERING ASSOCIATION

My name is Robert Bradford. I am the Executive Director of WEA, the Wichita Engineering Association. We represent over 2,200 members who work and live in Kansas, Oklahoma, Louisiana, California, and various Air Force Bases throughout the United States. We are pleased to submit this testimony to you and your committee, and we applaud the committee's decision to hold field hearings, which allow us to participate in the legislative process.

Being members of the scientific community, our members are deeply concerned about the direction in which our government is going with respect to support for scientific inquiry. In this era of deficits and competing programs, all seeking funds, we are aware of the budgetary constraints placed on our lawmakers. But at the same time, we recognize the long lead that exists between today's engineering and scientific research projects and the employment that results from the production of goods and the services required to maintain them. As engineers we appreciate even more the educational requirements that pre-date the entire process of design and production. Our engineers are the product of many years of education in the physical and natural sciences. We are keenly aware of the importance of planning for the education or our future scientists and engineers.

Our goal in submitting this testimony is to share with you the feelings of our members on the subject of your hearings. We are deeply concerned about preserving and expanding America's competitive edge in an era where a nation's competitiveness may well determine its viability as an international power. We also recognize that in the same way that today's competitiveness rests on the ideas generated from yesterday's students, today's students will hold the key for our nation to compete tomorrow. We endorse the committee's support for scientific education and the quest for new technologies.

Our members have given much thought to the question of research and development. In February of this year, the Council of Engineers and Scientists Organization, which represents scientists and engineers in more than forty states, adopted a resolution to petition our lawmakers to support the R&D function that crosses the entire specturm of scientific inquiry. We felt that this resolution so represented our sentiments that WEA adopted an identical resolution. It reads as follows:

"WHEREAS: The members of WICHITA ENGINEERING ASSOCIATION recognize that the number of present and future jobs in the Electronics and Defense industry depend upon public and private investment in new technologies; AND

"WHEREAS: We also recognize that America's competitive edge is directly related to our nation's commitment to R&D.

"THEREFORE: WEA resolves that it will petition our lawmakers to include in the budget continued sufficient and necessary funds and incentives for Industry to invest in new technologies to preserve and expand our competitive edge and thereby assure future employment for America's next generation in Science, Engineering, and Manufacturing."

In addition to the subject of R&D in general, this committee in particular is concerned with the programs of NASA. Here we feel that the views of our members are vitally important to your deliberations.

The United States has developed the strongest aeronautics industry in the world, in part through knowledge gained from the NASA Langley Research Center. The US government assumed a large portion of the risk by funding the development of the Langley Research Center in 1917 before anyone could even imagine that it would lead to the creation of a whole new industry.

Now the government is embarking on the development of our first permanently manned research center in space, called the space station, and it is expected that this new investment by our government will open the door to an entirely new US industry in space that will provide jobs for a whole new generation on earth.

Obviously, to those of us in Kansas, NASA contracts are important to the economy of the scientific community. Kansas is the recipient of $8 million in NASA contracts. But beyond that, we know that we are falling behind the rest of the industrialized world in bringing new technology into the commercial market place.

Space research is at the leading edge of America's technical growth. No where does the promise of future greatness shine more brightly than in the potential research benefits to be derived from a permanently manned space station. Support of the aerospace industry through continued emphasis on R&D will benefit the United

States in its trade deficit. Aerospace industry has the largest surplus trade balance of any industry in the country. Space is the one frontier that we can further exploit in support of those trade imbalances.

Let me conclude, Madam Chairman, by saying that today research projects, like the space station and other aviation R&D programs (many of which are, admittedly, under the direction of the Defense Department) hold the key to our future. The American work force is here to support that growth, that future and that continued greatness.

Aerospace Education: A Teacher's Viewpoint [1]

Aerospace Education in Kansas takes on many facets, but it should be understood from the beginning that the teachers, college professors, and other professional people involved in the various programs do not do so with the idea of teaching several thousand grade school children how to fly airplanes and space shuttles. At the elementary level, especially, Aerospace Education can span the entire timeline from the Montgolfier Brothers' balloon to the current space program. It is a building process, just as learning to read, or beginning math can be. It should be a program designed to stimulate children's thinking, make them aware of the world around them, and is often used as a springboard to the learning of basic curriculum.

In this paper, I will address five questions:

Why is aerospace education needed?

Is it a valid teaching tool?

Is it curriculum and objective oriented?

How is it available to teachers and students in Kansas?

Where do we go from here?

Why is aerospace education needed?

During the early pages of American history, children were taught at home, or attended small country schools when they were not needed on the farms. They often shared a primer, used slate and chalk to do their lessons, or even practiced writing numbers in the dirt with a stick. They used whatever materials were available to them.

Progressing through history, we began learning with paper and pen, then pencil; we went from the one precious copy of a MacGuffy Reader to mass production of textbooks in all subjects; and from the numbers in the dirt to the modern day computer. We are still teaching children with materials that are available, but it is technology and space that is now available, not slates and chalk. With the advent of the computer and video game, teachers have had to re-evalute their teaching methods in order to keep up with the students they teach! Kansas Cosmosphere Director Max Ary has stated that "today's students will be space science oriented, just as students in the 70's and early 80's were computer science oriented."

With the advent of the space station, and manned Mars landings, the students of today will have the opportunity to choose a career in space. This is not to say that they will all be astronauts; only a small percentage of the NASA applicants are accepted into this status. But there are innumerable careers related to the space program to consider—everything from mechanical engineering to home economics. Steve Hawley, in his comments to the Subcommittee, stated that individual motivation is needed by students to go into science and technology areas. The classroom is the ideal place for that motivation to begin. He went on to say that "Students need to be prepared as much as possible for unforeseen opportunity, however it appears." How are students to prepare themselves unless educators give them the opportunity to explore any and all interests?

Not only do we need to make children aware of the possibilities of a career in space, but educators need to be aware of the opportunities our space program has to offer them. Long distance learning is now available because of our satellite communications. Teachers can take continuing education classes through the telecourse network; foreign language can be presented to students via satellite receivers; teleconferences provide current, relevant instructional materials to both teachers and students, and provide the opportunity to interact with classrooms across the nation, or around the world.

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[1] By Barbara Baldwin, President-Elect, Kansas Commission on Aerospace Education, Young Astronaut, Chapter #522, Leader Director of School Services, KOOD-TV, P.O. Box 9, Bunker Hill, KS 67626.

Because of the American tradition of inventiveness and independent thinking, we have been able to put ourselves at the top of the technological world. But these same innovative methods have thrust our children into a Hi-Tech age, for which they will not be ready without our help. Even if the Space Program were to be discontinued today, we could not go back to the slate and chalk method of instruction. If we do not teach children at the level at which they are capable of learning, we are doing them an injustice!

IS AEROSPACE EDUCATION A VALID TEACHING TOOL?

Defining the term "valid" is a necessary pre-requisite to answering this question. If by "valid" you mean, "Aerospace is something that students will use day in and day out throughout their lives", then no, teaching aerospace is not valid. But then you would have to question the validity of a lesson on seasonal changes taught in Florida schools; or a lesson on hibernating bears to a child in Kansas, where there are no bears. Also questionable would be the math chapters on money to a child whose family is on food stamps.

However, if by "valid" you ask, "Do children learn from this experience?", then the answer is definitely, YES. In fact, they tend to learn more, retain it longer, and show more interest in the study of aerospace than some other curriculum areas. In the hopes of convincing the Wichita School System of just this fact, I conducted a study in my fifth grade class during the 1983–84 school year. A comparison was made between a basic English unit, and units on the Properties of Air (science) and Hot Air Ballooning. As many variables as possible were kept constant:

1. All lessons presented were combinations of teacher lecture, discussion and student worksheets.
2. The number of class periods spent studying the three sections was relatively close, although English received more time than did Science or ballooning.
3. Original tests in English and ballooning were given within a day of each other, and the retests on all sections were given on the same day.
4. The test and retest in each section was the same, so as not to confuse students with more difficult questions. The students, however, were not told in advance that there would be a retest.

The following is a table of the material covered, the amount of time spent in each area, and the original test dates:

SUMMARY OF MATERIALS STUDIED

Subject/Skill	Class periods	Total minutes	Test date (1983)
English—Patterns of Language	8	360	September 20
Sentence order.			
Basic sentence structure.			
Paragraph topics.			
Capitalization.			
Punctuation.			
Science—Properties of Air	5	175	September 7
Air can be seen.			
Air can be felt.			
Air holds things up.			
Air has weight.			
Air has pressure.			
Air takes up space.			
Ballooning	7	*305	September 21
Terminology.			
Basic facts.			
History.			
Reading selections.			

*This time included 90 minutes for a live balloon demonstration and a 40 minute writing period relating to balloons.

The original tests in each area were given at the end of the units. The earlier date on the Science test was due to the fact that it was done before the ballooning unit began, to give students a better background in the properties of air to understand how a balloon flies. Retests in all areas were given on the same day; December 19; three months after the original tests. The results of the retests are as follows:

RETENTION OF LEARNED MATERIAL

Subject	Percent of class retaining 50 percent or more	Percent of class retaining 100 percent
English	40	35
Sicence	95	70
Ballooning	70	70

The high retention of learned material evidenced by this study is caused by increased interest on the part of the students. Aerospace was new, different, and created an enjoyable learning environment for students. When taught in combination with basic curriculum areas, aerospace can provide a motivating tool for even the most reluctant student.

IS AEROSPACE EDUCATION CURRICULUM AND OBJECTIVE ORIENTED?

Although the study of Aerospace, and Space, can be most directly related to the Science curriculum, it is easily incorporated into all curriculum areas. Attached to the back of this report is a Curriculum Correlation Guide produced by the Civil Air Patrol, which shows the relationship of aerospace education to curriculum areas.

Even within the basic Hot Air Ballooning Unit done with the class of fifth graders, motivation, which starts in science, was transferred and sustained throughout the rest of the curriculum. Ballooning lent itself to related studies in History, Language Arts, Spelling, Reading, Economics and Math. It can also be incorporated into the Art and Computer programs.

There is strong evidence to indicate that this interest and motivation can be sustained over an extended period of time. Four months after the *end* of the ballooning unit, students wrote poems, articles, and drew pictures to submit for publication to Ballooning a national magazine. A request was made by the editor of the magazine, but the teacher did not make it a required assignment; and yet, twenty out of twenty-five students submitted papers.

The method by which aerospace is used in a classroom depends largely on the teacher. Some instructors will place more emphasis on the history of flight, while others may choose to investigate the literary aspects of the field, or relate compass reading to the learning of geography and math. This is the unique aspect about the teaching of aerospace—it is very compatible with all curriculum areas; it does not have to be a subject in and for itself.

Many schools today are concerned with reaching certain goals and objectives at each grade level, and determining whether students are competent in skill areas. Often, this stress on objectives and competencies leaves little time to relate what a child learns to the real world in which they live! In comparing only the hot air ballooning unit I did in class, it was found to meet 7 out of 12 Language Arts goals for the Wichita school district, and 6 out of 13 Literature goals. One motivating unit can help teach over half the goals for a year! One of the department directors shared the same formula for successful students that I did when he stated: "I don't care what they read, as long as they read."

The use of aerospace, in whatever curriculum area a teacher wishes, can produce satisfying results in terms of motivation, interest, and retention.

HOW IS AEROSPACE AVAILABLE TO TEACHERS AND STUDENTS IN KANSAS?

Kansas is fortunate in the resources it has available not only to teachers and students, but to the general public as well. Four major aircraft manufacturers—Boeing, Cessna, Beech, and Gates Learjet, are based in Wichita, and provide resources, jobs, and educational support. The Kansas Cosmosphere and Space Center in Hutchinson has the largest exhibit of Space related materials anywhere in the area, and continues its dedication to today's youth by offering the Future Astronaut Training summer camps. Wichita is also home for the Omnisphere and Lake Afton Observatory, both dedicated to the preservation of space information, and the dissemination of this information to schools and the public.

There are several other resources that do not have "home bases" or regular offices and office hours. These are the people in Kansas involved in aerospace education. The Kansas Commission on Aerospace Education is one such organization. Made up of college and university professors, teachers, aircraft industry personnel,

and interested people, the Commission works toward furthering the cause of aerospace education in Kansas. Their latest endeavor involved the republication of a series of articles by the Wichita Eagle Beacon on "Aviation Pioneers." The Commission worked with the four major aircraft manufacturers mentioned earlier, and the Eagle Beacon, to see that the articles were reprinted in a supplement fashion, a teacher's guide was designed, and the entire package was presented to the State Department of Education for distribution to 2,000 school libraries across the state. The Eagle Beacon is also making this supplement available to school teachers in classroom quantities at a price which is probably under what it cost to produce the material.

Teacher education is another aspect to the Commission's work. The college professors on the Commission also teach Aerospace Education classes each summer for graduate credit. These courses, designed for teachers, go over all aspects of aerospace education, from balloons to the space program. Teachers hear from Civil Air Patrol personnel, NASA specialists, and other teachers who have programs already in place. By the end of the class, individual teachers have become well-informed program specialists, and can go back to the classrooms ready to help their children learn about the world of airplanes and space. This summer, 6 Aerospace Education workshops will be held across the state during June and July. Kansas State University, Ft. Hays State University, Cowley County Community College, Kansas University at Lawrence, St. Mary's of the Plains, and Salina (through KSU) will all host workshops. The average enrollment in these courses is 25.

The Young Astronaut Program is also having its impact in Kansas, although not at the rate we would like to see. From its conception, chapters have sprung up at an amazing rate. Kansas now has 130 registered chapters, some of which are very active. The Young Astronaut Council uses the excitement and enthusiasm generated by the space program to motivate students to learn more in the areas of math, science, and technology. Teachers have learned about the program through workshops or personal contact with other chapter leaders, and many use it as an extension of classroom learning, a motivating tool, or an extra-curricular club. While teaching in Wichita, a Co-Op was started to help begin new chapters, and the student enthusiasm was so great we had to start 3 chapters at the Omnisphere. These meetings were held on Saturdays for 1 hour. How many other programs can claim that their participants willingly give up Saturday morning cartoons to go LEARN!? Last summer, the Kiwanis adopted the Young Astronauts as a Major Emphasis Clubs for support and resources. Currently, I am printing a quarterly newsletter for the Young Astronaut Chapters in Kansas to help this effort. The purpose is to share ideas and information among chapters, and to help keep teachers abreast of current issues and concerns.

In addition to people right in the state of Kansas who support aerospace education and provide the resources available to teach it, we have a regional Federal Aviation Administration Office in Kansas City, Missouri, which provides numerous educational publications and computer programs to all interested teachers. NASA also has regional centers, Reports to Educators, the Spacemobile, and teleconferences, all of which are available to the teachers of Kansas.

WHERE DO WE GO FROM HERE?

It would seem that Kansas is ahead of its time in providing aerospace education to its students and teachers, however, such is not the case. A few dedicated people are doing a tremendous job within the state to let people know what is available; but considering the number of schools and the number of students in the state, we are not reaching the majority.

Education needs to begin with the public; letting them know what is available in the state, what is being taught, and that it is a VALID curriculum subject that should be taught in the schools. Parents can lend a lot of support (and pressure) to make changes within their school districts.

School administrators need to be more informed about the subject, how it relates to curriculum areas, and how inexpensive it is to incorporate into the district plan. Many Superintendents and Principals hear "Aerospace Education" and believe we want to teach youngsters to fly planes. Aerospace Education is not how to fly—it is the history, literature, math, science, and even the mythology of our universe.

The State Department of Education has been very supportive in the past to the Kansas Commission on Aerospace Education and its efforts to distribute information. The ideal situation would be to have a State mandated Aerospace Education Curriculum, K–12 grades. This task already has a great deal of groundwork laid in Kansas, considering the efforts teachers are extending on their own. If a mandated

curriculum is not possible, it would be appropriate to have formal acknowledgment by the State Department of Education that the teaching of aerospace in grades K–12 is indeed a valid, curriculum and objective oriented, course of study. Many teachers, enthused about teaching balloons and airplanes, are informed that since it does not fall under the guidelines for goals and objectives, they cannot incorporate a unit into their classes.

No matter how informed parents, teachers, and administrators are about the importance and validity of teaching aerospace, it, and related curriculum areas such as science, are still areas that receive little or no funding. Dr. Wentz, Roskam, and Spooner spoke of the lack of funding for university programs, but it starts long before that. An example in point: While teaching a microscopic unit in Wichita, I found that over half the microscopes we had were unusable because of inferior quality. Of those which had lights, we had to move to another room to allow access to electrical outlets, only to find about ⅓ of the lights didn't work. Since these were supplied by school services, they had to be ordered, and would not arrive for 3 weeks. It was almost impossible to plan far enough in advance to know that your equipment and supplies would arrive on time. With usuable equipment and supplies not easily within reach, it is often easier (but not *right*) to either forget science altogether or to just have students read the book and forget the hands-on experiments that make science come alive.

The youth of our state, and our nation, are depending on us to guide them through the intricacies of learning and to help them become mature, educated adults. We should do no less than offer them our best!

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